DUAL TRACE OSCILLOSCOPE OS3300A

Instruction Manual

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ADVANCE

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Instruction Manual

ADVANCE INSTRUMENTS

Hainault Essex England

Telephone 01-500 1000
Telegrams Attenuate Ilford
Telex 263785

Division of ADVANCE ELECTRONICS LIMITED

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OS3300A 50MHz DUAL TRACE OSCILLOSCOPE

The Advance OS3300A is a 50MHz Lightweight dual-trace oscilloscope. Its facilities make it particularly suitable for General Purpose and High Quality laboratory work, and its size and light weight suit it for portable servicing applications of an exacting nature such as computers and data processors.

The high sensitivity and fast timebase speeds make the instrument ideal for the display of fast transients, and the comprehensive dual timebases allow detailed examination of complex waveforms and pulse trains. The mixed sweep facility gives continuous identification of the location of the section of waveform being examined.

Triggering facilities are independent for each channel, an essential feature for TV and pulse operation to eliminate waveform jitter.

Specification

Section 2

Display
8 x 10cm Rectangular faced CRT
EHT 12kV overall
Internal scale 8 x 10cm divisions with centre lines marked in 2mm divisions (Illuminated).
Phosphor P31 standard, P7 optional.

Vertical Deflection
Two identical input channels which may be operated in chopped or alternate modes, separately or summed.
Bandwidth DC – 50MHz (–3dB) DC coupled
2Hz – 50MHz (–3dB) AC coupled
Rise time <7ns
Input coupling DC – Ground – AC
Sensitivity 5mV/cm to 20V/cm in 1–2–5 sequence with uncalibrated fine gain control giving >2.5:1 reduction in sensitivity. Warning Light indicates uncalibrated setting.
A x5 facility on each channel gives maximum sensitivity of 1mV/cm with a bandwidth of DC to 10MHz.
Accuracy ±3% (±5% on x5)
Input impedance – 1MΩ/28pf
Signal Delay – at least 1 cm visible delay on fastest time base speed.
Maximum input volts (DC plus pk AC) 400V

Operating Modes
CH1 only
CH2 only
Channel CH1 and CH2 chopped (500kHz approx.)
CH1 and CH2 alternate
CH1 + CH2 (Algebraic addition)
NOTE: CH2 may be inverted

Horizontal Deflection

	'A' Timebase	'B' Timebase
Sweep Speeds	22 ranges covering 100ns/cm to 1s/cm in 1–2–5 sequence.	21 ranges covering 100ns/cm to ·5s/cm in 1–2–5 sequence
Fine speed control Warning lights indicate uncalibrated settings	Reduces speed by 2.5 times (slowest speed approx. ½ min)/x10 X expansion gives fastest timebase speed of 10ns/cm.	Reduces speed by 2.5 times/x10 X expansion gives fastest timebase speed of 10ns/cm.
Accuracy	±3% (±5% on x10)	±3% (±5% on x10)
Trigger Selection	Internal CH1, + or – slope Comp. + or – Internal CH2, + or – slope External , + or – slope Line , + or – slope Free Run	Internal CH1, + or – slope Comp. + or – Internal CH2, + or – slope External , + or – slope Line , + or – slope
Trigger Input coupling	AC, DC, AC LF Rej, AC HF Rej.	AC, DC, AC LF Rej, AC HF Rej.
Trigger level control	a) Manual b) Bright line auto (40Hz to 5MHz)	a) Manual (gated) after delay b) Direct sweep after delay.
Trigger sensitivity Internal:–	Manual – 2mm to 5MHz 1cm at 50MHz Auto – 3mm to 2MHz	Manual – 2mm to 5MHz 1cm at 50MHz
External:–	Manual – 300mV to 5MHz 1.5V at 50MHz Auto – 500mV at 2 MHz	Manual – 300mV to 5MHz 1.5V at 50MHz

Delay
10 turn delay control gives selection of 'B' timebase starting position.
Accuracy ±1% scale ±3% reading
Jitter <1 in 10,000 of scale
Linearity ±1.5%

Time Base Modes
'A' Sweep
'A' Intensified by 'B'
'B' Delayed by 'A'
'A' and 'B' mixed.

Horizontal Amplifier

x10 Expansion

Operates on all timebase modes giving fastest sweep speed of 10ns/cm. Accuracy ±5%.

Beam Finder:– Compresses trace to within scale area in determining the location or relative magnitude of an off-screen signal regardless of settings of vertical and horizontal position controls. A preset intensity level provides a constant brightness.

External X

Sensitivity 1V per cm
0.1V per cm on x10 expansion
Bandwidth dc – 5MHz
Input Impedance 100kΩ

XY OPERATION

CH2 output (rear panel) coupled to Ext. X input with x10 X expand. Bandwidth dc – 1MHz.
Phase shift <3° at 500kHz. Sensitivity as CH2 input attenuator (Y2 x5 inoperative)

Ext. Z mod. (rear panel)

Input Impedance – 47kΩ
Frequency Response – dc to 50MHz
Sensitivity: 1 volt for visible modulation at low intensity
+20 volts for blanking from normal intensity.

Outputs

Calibrator – front panel test points 0.1 and 1V pk-pk sq. wave ±1% 1 kHz. Current 1mA.

'A' Ramp rear panel 4mm socket 0 to +10V from <10kΩ
'A' Gate " " " " 0 to +10V from <10kΩ
'B' Gate " " " " 0 to +10V from <10kΩ

CH2 out. Rear Panel BNC socket.
Output: 100mV per cm deflection.

Supplies

95-111, 103-121, 111-130V) 45 to 440Hz
190-222, 206-242, 222-260V)
Consumption 70VA approx.

Operating temperature Range

–5 to +55°C.
Full specification is met over range 0°C–40°C

Size and Weight

7" (18cm) x 11⅜" (29cm) x 16½" (42cm)
27 lbs. (12kg)

Accessories supplied

Handbook P.No.32262

2 off BNC-BNC lead	PL43
2 off BNC-Clips lead	PL44
2 off 4mm plug	PN1244

Optional accessories

Viewing Hood	PN32264
Passive Probe Kit	PB10
Protective cover	PN32479
Trolley	TR4
Timebase Extension Lead	PL91

3.1 SWITCHING ON

CAUTION The OS3300A is convection cooled and must always be operated in a position such that air circulation through the bottom and top vents is not restricted.

1. Set the support/carrying handle to the required operating position. The handle is released by pulling outward both fixing bushes when it can then be turned to lock in any one of 5 positions.
2. ENSURE THAT THE SUPPLY VOLTAGE SELECTOR ON THE REAR PANEL IS SET TO SUIT THE VOLTAGE OF THE SUPPLY TO BE USED. The selector must not be operated while the instrument is switched on. Connect the supply.
3. Turn the INTEN control clockwise beyond the POWER OFF setting and ensure that the indicator lamp lights. A trace should be obtainable within 1 min. and full calibrated performance within 15 mins.

3.2 OBTAINING A TRACE

1. To obtain a trace
   (a) Set the MODE switch to CH1
   (b) Set the DISPLAY switch to A
   (c) Set the A TRIG. SELECT switch to FREE RUN
   (d) Set the timebase SWEEP switch to NORMAL
   (e) Operate the TRACE LOCATE push button
   (f) Centralise the display using the X and CH1 shift controls
   (g) Release the TRACE LOCATE button and set the INTEN control for a displayof the required intensity
   (h) Adjust the FOCUS control and ASTIG preset control to obtain a sharply defined trace.

If the TRACE LOCATE button is operated at any other time, the trace should appear. The appearance of the trace toward the top or bottom of the screen can be corrected by the relevant Y shift control unless there is an excessive Y input signal.

Similarly, deflection to either side in the External X modes can be corrected by the X shift control unless due to an excessive X input signal.

If the timebase is in use, the lack of horizontal deflection suggests incorrect triggering.

Once the trace is centred, the TRACE LOCATE button should be released and any necessary correction made to the INTEN setting.

3.3 SETTING UP Y CHANNELS

1. Using one of the coaxial input signal leads (PL43 or PL44), or a suitable probe, connect a signal to the CH1 or CH2 input socket.
2. For
   (a) Direct coupling of the input signal, set the associated AC, GND, DC input lever switch to DC.
   (b) Capacitive coupling of the input signal through an internal 0.1μF 400V capacitor, set the lever switch to AC.

NOTE When examining low amplitude ac signals superimposed on a high dc level, the lever switch should be set to AC and the sensitivity of the Y amplifier increased as in 4.

3. To locate the baseline, set the lever switch to the GND setting. At this setting, the input signal is open circuit and the input of the amplifier is switched to ground.
4. To adjust the sensitivity
   (a) Set the VOLTS/CM switch to a suitable setting. To minimise pick up at sensitive settings, it is essential to ensure that the ground lead connection is near to the signal point.
   (b) If necessary, adjust the concentric VARIABLE control.

NOTE The range of the VARIABLE control is uncalibrated. A warning UNCAL light mounted adjacent to the VARIABLE control is lit, once out of the CALIBRATED position.
At the CALIBRATED setting, the calibration corresponds to the setting of the VOLTS/CM switch.

5. For vertical movement of the trace, adjust the Y shift controls (identified with vertical arrows).
6. If, under no signal conditions, trace movement is detected when the VARIABLE is altered, reset the BAL preset control. If there is subsequent movement when the VOLTS/CM control is switched between ranges, the STEP BAL preset control should be adjusted. Access to this control is through the bottom cover.
7. Preset gain adjustment for each channel is available with access to the control through the bottom cover. This should be set for 5 cm of deflection on the 20mV/cm range with the input coupled directly to the 100mV calibrator output.

NOTE These preset controls will only need adjusting at infrequent intervals or after a large change of ambient temperature. They should not be adjusted within 15 mins. of switch on. Check that the input coupling switch is set to GND.

3.4 SINGLE TRACE OPERATION

1. For single trace operation on the CH1 channel, set
   (a) The MODE switch to CH1.
   (b) The CH1 shift control (indicated by double ended vertical arrow) to mid setting.
2. For single trace operation on the CH2 channel set
   (a) The MODE switch to CH2.
   (b) The CH2 shift control (indicated by double ended vertical arrow) to mid setting.
3. High sensitivity operation with a bandwidth of dc to 10MHz can be obtained on either channel by pulling the SHIFT control which increases the sensitivity 5 times, i.e. 1mV/cm with the sensitivity set to 5mV/cm
   2mV/cm " " " " 10mV/cm
   4mV/cm " " " " 20mV/cm
   Beyond this it is better to revert to normal operation.
4. It is possible to obtain useful higher sensitivities with unspecified overall performance by cascading the two channels. The input signal should be coupled into CH2 and the CH2.

OUTPUT socket on the rear panel coupled to the CH1 input using a coaxial connector PL43.

The MODE switch should be set to CH1. The CH2 output provides 0.1V/cm of normal CH2 display, i.e. an additional gain of x20. DC offsets and drift will necessitate the use of ac coupling in this mode and amplifier noise will negate the use of the full sensitivity of 50uV/cm.

3.5 DUAL TRACE OPERATION

In the dual trace condition, the beam switching function is in operation and results in the independent display of two signals simultaneously. Two modes of beam switching – chopped or alternate – are used, selected by the setting of the MODE switch. At any fast setting from 0.1μs/cm to 0.5ms/cm inclusive, the alternate mode is recommended. At slow settings from 1ms/cm to 1s/cm, inclusive and EXT X, the chopped mode is preferable. For EXT X the chopped mode is essential to give two trace operation.

1. For dual trace operation, set
   (a) The CH1 shift control to mid position.
   (b) The CH2 shift control to mid position.
   (c) Select ALT or CHOP on MODE switch.

3.6 A TIMEBASE OPERATION

The speed of the A timebase is determined by the setting of the A TIME/CM switch. In addition to selection of the speed of the internal timebase, the switch has a functional setting, EXT X in which the internal timebase is inoperative. The gain of the internal X amplifier may be increased by ten times by pulling out the PULL X10 control on the inner shift control. This facility is available at all settings including EXT X. The facility effectively increases the sweep length from 10cm to 100cm and thus allows close examination of any portion of the trace. Any portion of the increased sweep length may be selected for viewing on the display by adjusting the X shift controls (identified by horizontal arrows). The fine shift control will move the display by approximately 1cm when the PULL X10 is not operative and by 10cm in the magnified mode.

A particular advantage of this facility is to increase the maximum sweep speed to 10ns/cm.

1. To adjust the time scale of the horizontal axis
   (a) Set the A TIME/CM switch to the required setting.
   (b) If necessary, adjust the concentric VARIABLE

NOTE The range of the VARIABLE control is approximately 3:1. The VARIABLE control is uncalibrated and a warning light, adjacent to the VARIABLE control, lights in the UNCAL position. At the CALIBRATED setting only, the calibration corresponds to the setting of the TIME/CM switch.

Selection of the 1 sec/cm range and full use of the variable control, provides a total sweep time of approximately 0.5 min.

3.7 A TRIGGER

The A timebase may be operated in a FREE RUN condition or, more normally, triggered from the positive or negative slope of a signal as determined by the setting of the TRIG SELECT switch. The triggering sources selected by the TRIG SELECT switch are as follows.

(a) The supply line input frequency derived internally from the supply transformer.
(b) CH1 or CH2 amplifiers (irrespective of which beam is displayed).
(c) A composite of CH1 and CH2 signals.
(d) An external triggering source connected to the EXT TRIG socket.

The A LEVEL control concentric with the A TRIG SELECT switch, allows selection of the triggering point on the trigger waveform and hence determination of the start of the horizontal trace. When the LEVEL control is set to AUTO, the trigger circuit automatically biases itself to a sensitive trigger level condition. In the absence of a trigger signal in this mode, the timebase will free run and maintain a displayed sweep at the selected speed.

The TRIG SELECT switch is used in conjunction with the A TRIGGER COUPLING lever switch. This switch connects different networks into the trigger amplifier circuit and is effective at all settings of the TRIG SELECT switch.

The operating facilities available at the four settings of the lever switch are as follows.

1. AC Wideband trigger mode used for most common triggering signals.
2. AC. LF. reject. A filter is switched into circuit to reject low frequencies. High frequency triggering may be effected from complex waveforms such as those with high ripple content or line triggering from a television video signal waveform.
3. AC. HF. reject. A filter is switched into circuit to reject high frequencies. Low frequency triggering may be effected from complex waveforms containing high frequency components.
4. DC A wideband trigger mode but it is most useful at very low frequencies. The Y input coupling must also be dc for this mode to be effective on internal trigger.

Triggering control is effected as follows.

1. Set the A TRIG SELECT switch to select the required trigger signal.
2. Set the A TRIGGER COUPLING switch to the required setting.
3. On most waveforms it is convenient to select Auto. If not, adjust the LEVEL control so that the trace starts at the required point on the waveform.

If the timebase is not required to be triggered, set the A TRIG SELECT switch to FREE RUN.

NOTE 1 If, in the Auto mode, the frequency of the trigger is less than approx. 40Hz or the amplitude is too low for reliable triggering, the timebase automatically changes to a free run condition. This condition produces a trace at the selected sweep speed.

NOTE 2 As the COMP trigger signal is taken after the beam switch, its use is relevant only on dual trace displays in the ALT mode. Reliable triggering is obtained only with DC trigger coupling when the two traces overlap. In this mode the LEVEL control defines a point on the display rather than a level of input signal and the trigger point on the waveforms is altered with the Y shift controls.

The main application of this trigger mode is to display two signals of unrelated frequency. Relative phase relationship is lost when displaying signals of the same or related frequency.

3.8 SINGLE SWEEP FACILITY

To set the timebase to give a single sweep

1. Apply a repetitive waveform and obtain a trace with the SWEEP switch in NORMAL by adjusting the A LEVEL control.
2. Move SWEEP switch to SINGLE SHOT when triggering should cease.
3. Move SWEEP switch against the return spring arm and release.

The neon indicator will now light to show that the circuit is primed ready for the next trigger pulse to occur.

4. The next trigger pulse will initiate a sweep and the neon will be extinguished. The timebase will not again operate until the SWEEP switch is moved to the ARM position again..

3.9 B TIMEBASE AND TRIGGER

The speed of the B timebase is determined by the B TIME/CM switch, which has all the ranges of the A TIME/CM switch except 1s/cm. The B VARIABLE sweep speed potentiometer is concentric with the TIME/CM switch.

The B TRIG SELECT switch is identical to the A except that there is no FREE RUN position. The B LEVEL is identical to the A except that the AUTO function is taken by the B STARTS AFTER DELAY function. The B TRIG COUPLING switch is identical to the A.

3.10 DUAL TIMEBASE OPERATION – NORMAL DELAYED SWEEP

To examine a small period of a stable 'A' sweep

1. Set the B TIME/CM switch about two ranges faster in speed than the A TIME/CM switch.
2. Rotate B LEVEL control anticlockwise to the switched position, B STARTS AFTER DELAY.
3. Move DISPLAY switch to A INTEN BY B.
4. Adjust preset CONTRAST if necessary to give good visibility of the intensified portion of the trace.
5. Adjust B TIME/CM and the delay multiplier potentiometer so that the intensified portion covers the period of interest.
6. Move DISPLAY switch to B and make final adjustments of delay multiplier potentiometer and B TIME/CM switch.

3.11 DUAL TIMEBASE OPERATION – GATED SWEEP

If the display exhibits annoying jitter

1. Return display switch to A INTEN BY B.
2. Select appropriate trigger source, slope and coupling on the B TRIG SELECT and TRIG COUPLING switches.
3. With the B LEVEL still in the B STARTS AFTER DELAY position, adjust the delay multiplier so that the bright-up starts just before the edge of the waveform selected as a trigger point.
4. Rotate B LEVEL clockwise and adjust for a stable triggering by observing bright-up.
5. Move DISPLAY switch to B.

3.12 DUAL TIMEBASE OPERATION – MIXED SWEEP

This allows expansion of a part of the 'A' sweep while still displaying the 'A' sweep up to the point set by the delay multiplier.

1. Set DISPLAY switch to 'A' and obtain a display using the 'A' timebase controls only.
2. Set B TIME/CM switch two ranges faster in speed than the A TIME/CM switch.
3. Set B LEVEL to B STARTS AFTER DELAY.
4. Move DISPLAY switch to MIXED and adjust the DELAY multiplier potentiometer and the B TIME/CM switch for the best display. The CONTRAST can also be adjusted if necessary to allow for widely differing sweep speeds in the two sections of the trace.

3.13 EXTERNAL X

In this condition, the external signal is applied directly to the internal X amplifier to produce a calibrated (1V/cm) horizontal deflection. Dual trace Y operation may be used if chop is selected. Bandwidth is 5MHz.

1. Set the A TIME/CM switch to EXT X.
2. Connect the external signal to the EXT X socket.

3.14 X-Y MODE

It is possible to use the flexibility of the two Y inputs for XY displays.

1. Set the A TIME/CM switch to EXT X.
2. Set the CH2 input switch to DC or AC.
3. Connect the external signal which is to be used for X deflection to the CH2 socket.
4. Select x10 X amplifier gain.
5. Couple CH2 OUT (rear panel) to EXT X input with a coaxial lead PL43.
6. Operate the CH1 channel as for single trace operation and use the CH2 VOLTS/CM switch to control the X deflection. The CH2 shift is inoperative.

3.15 ADDITIONAL FACILITIES

3.15.1 USE OF OPTIONAL PASSIVE PROBE

A x10 passive probe may be used to extend the voltage range and increase the input impedance of the Y amplifiers. The input resistance of a Y channel is 1MΩ shunted

by approximately 28pF. The effective capacity of the input lead must be added to this and the resultant impedance will sometimes load the signal source. Therefore it is advisable to use a 10MΩ x10 probe. This reduces the input capacity and increases the input resistance, at the expense of the sensitivity. The probe contains a shunt RC network in series with the input, and forms an attenuator with the input RC of the Y channel. To obtain a flat frequency response it is necessary to adjust the capacitance of the probe to match the input capacity of the Y channel as follows.

1. Set the Y channel VOLTS/CM switch to 20mV/cm, and the A TIME/CM switch to .2ms/cm.
2. Connect the probe to the CAL 1V pin.
3. Set the adjustable capacitor in the probe tip or termination with a small screwdriver for a level response with no overshoot or undershoot visible on the display.

3.15.2 CAL 1V and 0.1V OUTPUTS

These pins provide dc coupled positive going square waves of 1v ± 2% and 0.1v ± 2% at 1KHz ± 1% frequency for calibration checks. The source impedance (1 Volt position) is 1KΩ and the rise time is 100ns.
Shorting the two pins will produce a square current waveform of 1mA in the shorting link. This can be used for current probe calibration.

3.15.3 'A' AND 'B' GATE OUTPUTS

These sockets on the rear panel provide a dc coupled positive going square pulse of 10V amplitude from <10kΩ source impedance. The duration of the pulse is coincident with the appropriate time base sweep. Improved rise time may be obtained at the expense of amplitude by resistively loading the outputs.

3.15.4 'A' RAMP

This socket on the rear panel provides a dc coupled positive-going timing ramp of approximately 10V amplitude generated by the 'A' timebase. Source impedance is 4.7kΩ and the ramp may be used as a drive for external frequency swept oscillators to allow display of voltage against frequency.

3.15.5 Z MOD

This socket on the rear panel allows dc coupled blanking to be applied to the tube.

The CRT trace is intensified by a negative input, and blanked by a positive input. The required amplitudes are

(a) 2 volts for visible intensity modulation.
(b) +20 volts for blanking at normal intensity.

This facility is available in any operating mode of the instrument.

For convenience, the circuit reference of any component can be used to determine its location in the instrument.

1	– 99	Frame or interconnection.
100	– 199	CH1 and CH2 Preamplifiers and attenuators.
200	– 299	Beam switch and delay line drive amplifier.
300	– 399	Delay equaliser and Y O/P amplifier.
400	– 499)	'A' Timebase
500	– 599)	
600	– 699)	'B' Timebase
700	– 799)	
800	– 899	Power supply and EHT supply.
900	– 999	Bright up amplifier and X output amplifier.

e.g. R374 is part of the Y output amplifier
D801 is part of the EHT oscillator.

The circuit diagrams are generally arranged for each printed board assembly or group of boards. These diagrams include some of the switches, potentiometers etc., closely associated with the circuit although these components may be mounted on the frame. Consequently not all such components appear on the interconnection diagram fig. 11 and where it makes the circuits easier to follow, some components appear on more than one circuit.

In addition to the relevant circuit diagrams, useful reference can be made to the waveform diagrams, figs. 12 and 13, when following the description of the timebase section.

4.1 THE BLOCK DIAGRAM

The block diagram for the complete instrument is shown in Fig. 1. It is not intended to be a full logic diagram but details the functional points of the circuit and their interrelation. The circuit can readily be divided into two main sections which are the Y and the X deflection circuits. The latter includes the two time bases with their associated trigger systems. The bright-up or Z modulation function is described as part of the time base function.

The main X and Y signal paths for a dual trace display using the main A sweep only, are indicated by the heavy lines.

Y CHANNELS

The switched attenuator, preamplifier and trigger amplifiers are identical for the two Y channels. CH2 differs in having invert and output facilities. The state of the decade steps of attenuation and 1, 2, 5 sequence of preamp gain switching are determined by the sensitivity selected.

The use of the x5 GAIN on each channel increases their basic sensitivity to 1mV per centimetre but reduces the overall bandwidth to 10MHz.

The channel switch is a fast electronic switch with the equivalent of a changeover action as shown. It selects either the CH1 or the CH2 signal to be passed to the subsequent stages and is controlled from a bistable. In the chop mode the bistable is driven by continuous pulses from the free running multivibrator, switching the beam between the CH1 and CH2 signals as the X sweep progresses. In the alternate mode, the multivibrator acts as a monostable generating a single pulse to reverse the beam switch at the end of each time base sweep, giving alternate CH1 and CH2 sweeps. In the ADD mode, both the CH1 and CH2 switches are closed and the two signals are summed algebraically. On CH1 or CH2 only the appropriate switch is closed allowing that signal to pass.

The signal from the selected channel is passed via a delay line and amplifiers to the Y deflection plates of the CRT. This delay allows examination of that point in the waveform which initiated the sweep because the deflecting signal reaches the Y plates after the time base sweep has been initiated and the trace brightened.

THE TIMEBASES

The purpose of the timebase system is to generate a linear ramp or ramps to deflect the spot in the X direction. The trigger system initiates each sweep from the incoming or other signals, normally to obtain a stationary display of a repeated waveform.

TIMEBASE 'A' OPERATION ONLY

The internal or external signal as selected is amplified by the trigger amplifier to drive a trigger circuit. If the timebase is ready to commence a sweep, a transition of the trigger circuit will set the 'A' timebase bistable which in turn initiates the 'A' ramp. This signal is passed through the X gate and X output amplifier to the X deflection plates of the CRT. At the end of the sweep, when the ramp reaches the required level the bistable is reset, returning the ramp to its original level. During the period of sweep the trigger gate is prevented from passing trigger pulses to the bistable and this inhibition is maintained by the hold off circuit until the ramp generator is fully recovered, ready for the next sweep to commence on the next trigger pulse, when the cycle repeats.

The bright-up amplifier normally holds the CRT beam in the cut off state. The output of the 'A' bistable which allows the 'A' ramp to operate, also feeds the bright-up amplifier to raise the intensity of the CRT spot to the level determined by the intensity control.

At the end of sweep, this output of the bistable is reset and blanks the trace during the flyback period.

If the Y channels are being switched in the chopped mode, the differentiated output of this multivibrator is also fed to the bright-up amplifier to blank the trace while the Y switching transition takes place. This leaves the appearance of two separate traces for CH1 and CH2 on the screen unless the sweep speed is higher than that normally recommended for chop operation.

'A' INTENSIFIED BY 'B' ('B' starts after delay)

In this mode operation of the 'A' ramp is the same as for 'A' only. The 'B' timebase bistable is switched on at the required point in the 'A' sweep when the 'A' ramp reaches the potential set by the delay control detected by the comparator. The 'B' ramp generator then runs either for its full period or until the end of the 'A' ramp, whichever occurs first, when the 'B' bistable is reset. The 'B' single shot bistable ensures that there is only one 'B' sweep during any 'A' sweep. The output of the 'B' bistable drives the bright-up amplifier to brighten the 'B' portion of the 'A' trace above the normal level, the relative level of the normal to brightened portion being determined by the contrast control setting.

'A' INTENSIFIED BY 'B' – GATED

In this mode the operation is as outlined for the normal intensified mode except that the output from the comparator only opens the 'B' timebase bistable trigger gate, allowing the next 'B' trigger pulse to trigger the bistable and hence initiate the 'B' ramp.

'B' ONLY

In this mode, the 'A' and 'B' sweeps are triggered and run as in the intensified mode. However, the X gate allows only the 'B' sweep signal to the X amplifier as the deflecting signal. The resultant display is then that section brightened up in the previous mode, now expanded to the full screen width. In this mode, the trace is only brightened during the 'B' sweep.

MIXED 'A' AND 'B'

This mode is a combination of the 'A' and 'B' modes. The 'A' sweep is triggered and runs as normal until the 'B' sweep starts as in the intensified or 'B' modes. During this time the 'A' ramp is fed via the 'B' ramp generator to the X gate to deflect the trace. This 'A' ramp connection also ensures that the 'B' ramp generator starts from the correct point. When the 'B' bistable is energised, the 'B' ramp runs, starting from the 'A' level at that instant and this ramp is passed by the X gate to increase the sweep speed to the 'B' rate. When the 'B' ramp reaches the normal end of sweep level, the 'B' timebase bistable is reset, in turn resetting the 'A' timebase bistable allowing the cycle to repeat after the 'A' hold off period.

The bright-up circuit operates as in the 'A' intensified by 'B' mode, allowing the contrast control to be used to equalise the brightness of the 'A' and 'B' portions of the trace despite the differing sweep speeds.

TRIGGER MODES

The trigger signal for either time base, selected from internal, external or line frequency sources, is ac or dc coupled before being fed into the trigger amplifier which is biased by the required trigger level and the resultant output passed to the trigger circuit to be squared up.

In the FREE RUN mode, the 'A' trigger gate is permanently energised and the 'A' timebase bistable is set again at the end of each hold-off period.

When AUTO coupling is selected, the 'A' trigger amplifier is automatically biased to the optimum working point for sensitive operation of the trigger. If the signal level out of the trigger amplifier is insufficient to operate the trigger circuit, a further output from the auto circuit causes the 'A' timebase to free run, displaying the necessary bright line trace.

In Single Sweep, the relevant bistable normally inhibits trigger pulses from reaching the 'A' timebase bistable. When the single shot bistable is set manually, the trigger gate is opened and the next trigger pulse initiates a sweep. When the sweep starts the single sweep bistable is reset, preventing the timebase from sweeping more than once.

THE EXTERNAL X I/P

When external X is selected, the trace is brightened and the timebases are inhibited. The amplified X input signal passes through the X gate to the main amplifier.

4.2 INPUT ATTENUATORS AND PREAMPLIFIERS

NOTE The Attenuator and Preamplifiers in the CH1 channel are identical to those in the CH2 channel. Accordingly, only the CH1 channel is described. Where a corresponding component carries a different number in CH2, this number is shown in brackets after the CH1 number.

The input signal is applied from the front panel socket SKY to the 3 position lever switch, S10. When the INPUT COUPLING SWITCH is in the DC position, the input signal is coupled directly to the Input Attenuator stage. In the AC position, the input signal passes through C155. This capacitor prevents the dc component of the input signal from passing to the amplifier. The GND position opens the signal path and connects the input circuit of the amplifier to ground. This provides a ground reference without having to disconnect the applied signal from the input connector.

The input attenuators are frequency compensated, voltage dividers. For dc and low frequency signals they are primarily resistance dividers and the attenuation is determined by the resistance ratio, the effect of the capacitors being negligible. However, at high frequencies, the reactance of the capacitors decreases and the attenuator becomes primarily a capacitive divider. Each attenuator contains an adjustable series capacitor to provide optimum response for the high frequency components and an adjustable shunt capacitor to set up the input capacity of each section. The component values in each section are arranged to provide the required attenuation and present the same RC characteristic for all settings of the VOLT/cm switch.

Two attenuator sections are employed giving an attenuation of 10 or 100 respectively. These are used singly or cascaded. The basic amplifier provides a maximum sensitivity (for full bandwidth) of 5mV/cm; gain switching in the amplifier reduces this to provide the 10mV/cm and 20mV/cm settings. The x10 attenuator is introduced to provide the 50, 100 and 200mV/cm ranges; the x100 to provide the 500mV, 1V, 2V/cm ranges and the x100 and x10 cascaded to provide the 5, 10 and 20V ranges.

The x10 attenuator consists of R176 and R177. Capacitor, C165 adjusts the input capacitance on the 50, 100, 200mV/cm ranges, while C167 corrects the frequency response of the attenuator.

The x100 attenuator consists of R163 and R169. Capacitor C159 adjusts the input capacitance on 500mV, 1V, 2V/cm ranges, while C161 corrects the frequency response of the attenuator.

Capacitor, C171 provides adjustment for the input capacity when the attenuators are not in circuit. R187 determines the input resistance of the oscilloscope when the attenuators are not in circuit and contributes to the attenuating resistors on all other ranges.

The output from the attenuator is taken via the input current limiting resistor, R189, to the input stage consisting of the source followers, TR101 & TR102, with its current source, TR102. These f.e.ts are matched and thermally coupled to minimise any drift due to temperature changes. The output from this stage is connected to the emitter follower, TR103, to provide a low impedance drive to the following stage. The second output from the preamplifier, the balance control voltage set by the front panel fine gain BALance, R11(21), is coupled via emitter follower, TR104, to the next stage. Transistors, TR103 and TR104, are selected and thermally connected to minimise any drift due to temperature changes.

The output from the emitter followers is applied to the long tail pair amplifier, TR121 and TR122. TR120 being a constant current source of this stage. The stage provides a nominal gain of about 5, the emitter circuit however contains the FINE GAIN CONTROL, R10 (R20), which allows a reduction in gain of at least 2:5:1. When the fine GAIN CONTROL is switched out of the CALIBRATED position S13 (S23) closes and the l.e.d., D123, is illuminated. The two transistors in this stage are matched and thermally coupled together in order to reduce drift to a minimum. In addition, they are mounted on the rear screen of the attenuator assembly in close proximity to the FINE GAIN CONTROL. This ensures that the length of the emitter leads to the gain control and consequently their inductance is kept to a minimum.

A potentiometer, R123, is provided in the emitter circuit giving some variation of the collector currents. This allows the emitter potentials of the following stage to be equalised to prevent trace movement when gain switching.

The collector supply is stabilised by the 5.6V zener diode, D121, giving a collector potential of +4V. This provides sufficient margin to allow for variations of input dc level due to the possible range of FET source to gate voltage.

The following stage is also a long-tailed pair with gain switching incorporated into the emitter circuit. In the minimum gain condition the gain is determined by the emitter resistors, R132 and R134. The gain is raised by x2 and x4 by connecting between the emitters network, R137 and R138, or network, R135 and R136, respectively with the two trimmers, C122 and C123, providing a high frequency compensation to equalise frequency response between ranges. Decoupled resistors, R154 and R155, are added to reduce collector dissipation and keep drift due to thermal effects to a minimum. The collector supply is stabilised by the 5.6V zener, D122.

The final stage on this board and on the attenuator assembly is a pair of emitter followers, TR125 and TR126.

The trigger signal is taken directly from the emitters but the signal for the remainder of the Y amplifier is tapped down the emitter loads by the addition of a small series resistor. This allows a dc shift of the output to be provided for, balancing in the following stage by the addition of the potentiometer, R146, in the bottom end of the emitter loads.

The signal outputs from this stage represent approximately 25mV/cm of screen deflection, the dc level being nominally +7.5 volts.

The signals are then passed to the Beam Switch printed circuit board, in the case of CH1 direct but in the case of CH2 via the INVERT `SWITCH, S201.

4.3 BEAM SWITCH

The CH1 and CH2 signals feed to the beam switch printed circuit board into two identical long-tail pair amplifiers, TR203/4 and TR205/6. Each amplifier provides a number of additional functions, namely:

1. SHIFT CONTROL is obtained by means of potentiometers, R26 and R27, in series with the emitter resistors of each stage.
2. Overall gain adjustment of each channel is provided for by means of the two networks, R226/R227 and R231/R232.
3. The maximum sensitivity of both CH1 and CH2 channels can be increased to 1mV/cm, this requires that the gain of these stages is increased by five times and is achieved by shunting across the emitter circuit the network, R228/R229 for CH1 and R233/234 for CH2. The switch for this function is mounted on the rear of the respective shift controls.
4. Networks, R230/C202 and R235/C206, are included to allow the h.f. response of the two channels to be matched.

The signals from this pair of amplifiers are fed to the beam switch circuit consisting of eight diodes, D201 to D208 inclusive. The switch is operated by signals applied in antiphase to points 26 and 29 from the Beam Switch Bistable. The signal level at these points switches from approximately +7V to approximately +0.3V. Thus when point 26 rises to +7V diodes, D201 and D202, are cut-off and diodes, D203 and D204, are turned on allowing CH2 signals to pass to the following stage. At the same time, point 29 will be at approximately +0.3V allowing D205 and D206 to conduct and prevent CH2 signals reaching the following stage. When the potentials on points 26 and 29 reverse, CH2 signals will pass to the following stage and CH1 signals will be blocked.

The output from the beam switch network is taken to transistors, TR210 and TR211, connected as shunt feedback amplifiers with R249 and R250 providing feedback from the collector to base of the respective transistor. Provision is also made in this stage by means of A.O.T. resistors, R294/R295, to take out small unbalances which cause excessive trace movement when switched to the ADD mode. Also in the ADD mode it is necessary, since two stages are now connected to a common load, to remove half the resultant current in the load, this is achieved by returning R245 and R246 to the −15V line when switching to ADD.

Signals from this stage pass to the delay line driver, a further long tail pair, TR212/TR213, fed from a constant current source, TR214. A current of 10mA per side is common to this stage and, via the delay line, to the delay line terminating stage.

The Beam Switch Bistable consists of transistors, TR215 and TR216, the conducting state of these determining which channel is displayed. For single trace operation, either of the emitters is grounded via points 35 and 36. For dual trace operation, both emitters are grounded and the transistors are turned on or off by pulses from TR217 routed via capacitors, C213 and C218, and diodes, D212 and D211. In the ADD mode both emitters are open circuited raising both collector voltages and hence opening both diode gates.

The chop multivibrator contains transistors, TR217 and TR218, which operate as an emitter-coupled astable multivibrator whose frequency of approx. 500kHz is determined by R280, R285, and C221.

In addition to operation for the chop function, the circuit acts as a monostable when the alternate mode of beam switching is selected. In the alternate mode, the circuit produces 1 pulse per timebase sweep and is fed with an end of sweep pulse from the time base bistable. The −15V volts supply is connected to point 32 via the FUNCTION SWITCH, this increases the current through TR218 and causes a drop in the level of the collector voltage.

This drop cuts off TR217. The negative going end of sweep pulse thus finds the circuit in a monostable condition which it triggers producing a high amplitude positive-going pulse at the collector of TR218 and a negative-going pulse at TR217. The output from TR218 is taken to the Bright-up Amplifier to blank the trace during the chop transistion period and that from TR217 to the Beam Switch Bistable.

4.4 DELAY LINE AND DELAY LINE EQUALISER

The Delay Line is of the wound type and introduces a signal delay of approximately 95ns. This time allows for delay in the time base and bright-up circuits and ensures that the first part of a signal is visible.

The output of the delay line is terminated by the resistors, R301 and R302, and feeds into the common base stage, TR300 and TR301.

The Pulse response compensation for the delay line is provided in the following stage, TR302/TR303, by means of resistance/capacitor networks, R308/C302, R309/C303, R310/C305, R311 and C306, connected between the emitters.

A further stage, TR304/TR305, provides additional frequency compensation (C310, C311, R324/C312) and raises the signal to the required level to drive the output stage.

4.5 OUTPUT STAGE

The output from TR304 and TR305 feeds the grounded base pair, TR356 and TR357. From this stage the signal drives into the differential input pair, TR351 and TR352. These two transistors, together with TR353 and TR354, operate as a differential cascode amplifier.

The collector loads are made up of two resistors in series/ in order to give the required dissipation with minimum stray capacitance. High frequency compensation is provided by the inductances, L351 and L352.

A constant current transistor, TR355, gives a current in each side of the output stage of approximately 35mA and holds this stable against small variations of the dc input level of +2.4V. At this current the nominal mean Y plate potential is +60V.

4.6 Y TRIGGER AMPLIFIERS AND CH2 OUTPUT AMPLIFIER

Incorporated on the Beam Switch printed circuit board are the CH1, CH2 and composite, trigger amplifiers and the CH2 output amplifier stage.

The CH1 and CH2 trigger amplifiers consist of long-tail pairs, TR201/TR202 and TR207/TR208, receiving differential signals from the the CH1 and CH2 pre-amplifiers and providing single ended output for the Time Base.

R213 and R223 provide a means of setting the d.c. level for the trigger circuits (nominally 0V).

In addition a further output is taken from the CH2 trigger amplifier and fed to an amplifying and inverting stage, TR209. This provides an output level of 100mV/cm and when used in conjunction with the X amplifier, gives an X-Y operation facility.

The gain of this stage can be set by R238 and phase shift correction is provided by C228 connected across the feedback resistor, R242.

The composite trigger input signal is taken from the main Y signal at the collectors of TR210 and TR211. This differential voltage is applied to the long tailed pair, TR219 and TR220, to provide a single ended output.

4.7 "A" TRIGGER SELECTION AND AMPLIFICATION

Trigger sources (CH1, CH2, composite, Line, Ext) are taken to S40AF. The internal trigger signals are brought via 50Ω coax, and are terminated by R400, R406 and R480. The line trigger signal is provided from a single turn secondary winding on the mains transformer and the correct trigger voltage is obtained by the simple attenuator, R405 (mounted on S70) and R746. External trigger signals are attenuated approximately fifty times by the network, R401, C400, R402 and C401. The signal selected by S40AF is passed via the trigger coupling switch, S42, to two cascaded emitter-follower stages, TR409 and TR410. D406 and D407 provide the necessary protection against excessively large external trigger signals. The signal from the emitter of TR410 is switched by S40BF and S40BB, according to the selected trigger slope, to the base of TR413

or TR414 which form a long-tailed pair amplifier. S40BF, S40BB also connect the undriven base of this amplifier to the network, C451, R437, and R420, which provides a low impedance path to ground for high frequency signals and the correct bias to balance the amplifier. The trigger level control (R440) also acts on this network via R441, introducing a positive or negative offset, which is thus mixed with the amplified trigger signal.

The network, R422 and C415, between the emitter of TR413 and TR414, provides high frequency compensation. The output from TR414 is applied to the base of TR415 which together with TR416, forms another long-tailed amplifier; R488, R490 and C424 provide high frequency compensation. The base of TR416 is normally held at a fixed bias by zener diode, D423, except when S41b (the auto level switch) is open (see Auto operation). When the level control (R440) is adjusted so that the base potentials of TR413 and TR414 are equal, R453 adjusts the dc potential on the base of TR415 so that the Schmitt trigger circuit is brought near its switching point, maintaining the same trigger level for positive and negative slope selection.

The output from the collector of TR415 is taken via D402 (See trigger signal routing) to grounded-base amplifier, TR404, and from the collector of this transistor via D401 to the Schmitt trigger circuit. The output from TR416 collector is connected to the auto level circuit.

4.8 AUTO

When auto is selected by turning the 'A' trigger level control to its extreme anticlockwise position, S41a and S41b open. R491 and the base of TR416 are disconnected from the zener diode, D423, so that the dc potential set by R453 has little effect on the amplifier, TR415 and TR416. The opening of S41 causes the potential at the extreme anticlockwise end of the level control to change from −15V approx. to 0V approx. (R440 and R552 form a potential divider across the ±15V lines). Thus the amplifier, TR413/TR414, is still approximately balanced. S41a also operates on TR403 (see Trigger signal routing) to energise the bright-line circuit. (See Free run and bright-line circuit). Trigger signals from the collector of TR416, are coupled via C411 and C412 to the bases of the complementary amplifier stage, TR406 and TR407. Emitter resistors, R426 and R427, define the gain, and C442 and C443 provide high frequency compensation. Both transistors are normally biased off but are sensitive to small input signals with one or the other being turned on. The output resultant from the commoned collectors is an amplified form of the input which is not paralysed by inputs of widely differing mark/space ratio. It is applied via D416 to grounded base stage, TR404, and thence to the Schmitt trigger.

4.9 "A" and "B" TRIGGER COUPLING

The selected triggering signal is taken to the coupling switch, S42 (S72 on the "B" Time Base), where a simple filter is connected into the signal path on all modes except dc coupled. In the AC connection, C402 (C611) removes the dc component. In the HF reject mode the time constant of R407/C466 (R758/C657) rolls off the response of the amplifier to high frequency signals. In the LF reject position the trigger signal is coupled via the small value capacitor, C403 (C610), whose impedance at low frequency forms an effective attenuator with the input resistor of the trigger amplifier to l.f. signals.

4.10 "A" TRIGGER SIGNAL ROUTING

The different trigger circuit connections, manual or auto trigger, are controlled by the state of TR403/TR405, and the position of the trigger coupling switch, S42. In manual operation, S41a is closed and with no voltage across its base resistor, R552, TR405 is cut off. Current through R439 and R421 turns on TR403 causing its collector potential to become approximately −15V. Current through R424 and D410, pulls the collector potentials of TR406 and TR407 negative, cutting off D416, and disconnecting the auto circuit output from the grounded base amplifier, TR604. Current through R418 acts on the bright-line circuit (see Free run and bright-line circuit), to prevent it operating. Trigger signals from TR415 are passed to the Schmitt trigger as current from TR415 flows through D402 into TR404, and from the collector of TR404 via D401 to the Schmitt trigger.

When Auto is selected, S41a is open, base current through R552 bottoms TR405, and this in turn cuts off TR403. Current through R408 and D435 causes the collector of TR415 to go negative, cutting off D402. At the same time, the current through R424 and D410 is removed allowing the collector potentials of TR406 and TR407 to rise, turning on D416. Trigger signals now pass from the collector of TR416 to the auto circuit, TR406 and TR407, and then via TR404 to the Schmitt trigger. Also, when TR403 is cut off, current through R418 is removed, energising the bright-line circuit, TR411 and TR412, and diode D404, is turned on by current flowing through R422 enabling the Schmitt trigger output waveform to drive C407. (See Free run and bright-line circuit).

4.11 "A" SCHMITT TRIGGER

This consists of TR401, TR402 and associated components. When the base of TR401 is negative with respect to ground, TR401 is off and TR402 is on.
R471 and R416 bias the base of TR402 about 0.5 volt positive. When the base voltage of TR401 is driven positive it will start to conduct. R416 provides positive feedback causing a rapid transition to the opposite state with TR401 conducting and TR402 cut off. When the base of TR401 returns negative, the switchover will occur at a lower level because of the change in potential across R416. This backlash prevents the trigger from responding to low level noise when biased to its operating point.
C404, R414 and C405 provide high frequency compensation of the feedback network. The output from the collector of TR402 is differentiated by C420 to operate the timebase bistable, and also via D404 and C407 to the

bright-line circuit as follows.

(a) **FREE-RUN AND BRIGHT-LINE CIRCUIT**

When Free run is selected by S40, −15V is connected to pin 9, and TR403 and TR405 are cut off by diodes, D403 and D405.

In turn, TR411 is cut off and the negative movement of its collector is passed by emitter-follower, TR412, to R462.

Current in R465 is switched from D419 into D420 and D421 to the base of TR419, turning on the timebase bistable. At the end of the sweep the hold off current from R458 will exceed that from R465, turning off the bistable for the hold-off period.

At the end of the hold-off period, the base of TR419 goes negative and the timebase bistable is again turned on. The cycle repeats as long as Free Run is selected.

When Auto is selected, TR405 is turned on, turning off TR403 and causing the time base to free run as above. When trigger signals are received and operate the Schmitt trigger, trigger pulses are routed from the Schmitt to the base of TR411. The negative transition of the collector of TR402 is transferred by D404, C407 and D415 to the base of TR411. As this transistor turns on, the rise of its collector potential is transferred via TR412, D418 and C418 in a regenerative loop to its emitter, so that TR411 bottoms, and the emitter of TR412 follows. This action inhibits the free run bias from R465 to the time base bistable and is maintained for approx 40ms, determined by C418 and R430. If no further trigger pulse is received in this period, the system will return to its free run condition. However, the regenerative action caused by any trigger pulse can be initiated at any point in the discharge of C418, and when the time base is being triggered at medium and high frequencies, the system is permanently biased in the condition which allows normal triggered operation.

4.12 "A" TIMEBASE BISTABLE

TR419 and TR420 form the emitter-coupled trigger bistable. R470 normally biases on TR419 and the low potential across R479 holds off TR420.

A negative transition from the Schmitt trigger is coupled via C420 and D421 to turn on TR419. The positive movement of the collector of TR419 is transferred by R479 to hold on TR420 and the bistable is reversed.

The collectors of TR421 and TR422 provide the two buffered outputs from the bistable. TR421 provides the "A" bright-up current pulse to the bright-up amplifier. The alternate beam switching pulse is provided from TR422 via C432 and emitter-follower, TR430. When TR420 is turned on, its collector potential falls and the diode, D422, conducts to initiate generation of the "A" ramp as described in section 4.13. The effect is that the emitter of TR432 goes negative until D431 is brought into conduction when TR420 is turned off and the bistable reverts to its initial condition, ready for the next trigger pulse via D421.

4.13 "A" RAMP GENERATOR

The basic ramp generator is the bootstrap feedback circuit formed by F.E.T., TR426, as a source-follower with two subsequent emitter-followers, TR427 and TR428. The base-to-emitter voltages of these two transistors are approximately equal and opposite so that the emitter of TR428 follows any change of gate voltage on TR426 with an offset which is the gate to source voltage of TR426, plus the potential across R514. The current in TR426 and hence the voltage between its gate and the base of TR427, is held constant, independent of actual potential as this current is the collector current of the grounded-base transistor, TR435.

Consequently there is a constant voltage across the selected timing resistor, Rt which in the absence of other influences, flows to ground through the selected timing capacitor Ct causing the voltage across this capacitor to drop linearly. This linear ramp, appears similarly on the emitter of TR428, is transferred to the emitter of TR432 and goes via the diode gate, D432 and D433, to the X gate. It is also tapped off via R547 to the 'A' ramp output amplifier, as described in section 4.21.

The sweep speed, that is the ramp slope, is determined by the values of Ct and Rt which are selected for a particular range. Details of this range switching is shown in fig. 5.

The third factor to control the sweep speed is the gate-to-source voltage of TR426. This F.E.T. is matched in characteristics with TR425. As both devices carry the same current, being coupled via the grounded base transistor TR435, and as R512 is equal to R514, the voltage between the gate of TR426 and the base of TR427 is equal to the voltage between gate and source of TR425, plus the voltage across R512. The latter voltage sum is set by resistor network, R511, R508 and R509, together with the preset calibration control, R510, and the variable sweep speed control, R507.

When the variable control is moved from the CALIBRATED position, S74 closes enabling the led, D441, to light.

During the flyback period when the time base bistable is reset, D422 is biased off and current flows through R540 into the emitter of TR431 and so to D429. This current is much greater than the current through Rt, so that the timing capacitor Ct is charged rapidly positive, and the emitter of TR428 follows until it approaches zero potential. At this point, TR429 conducts, diverting current from TR431. This subsequent reduction of the current in D429, limits when it balances the current through Rt. This is the quiescent point of the ramp generator with the emitter of TR428 and the collector of TR435 approximately at zero, and the voltage on the gate of TR426 at +4V. When the timebase bistable is switched by a trigger pulse, D422 is turned on, removing completely emitter current from TR431 and reducing the current in D429 to zero. The normal ramp action then takes place with the constant current through the timing resistor, Rt negatively charging the capacitor, Ct. The capacitor charges linearly until the emitter of TR432 is at about −4V, when D431 conducts to reset the timebase bistable and complete the cycle.

4.14 HOLD-OFF

Triggering of the timebase bistable must be prevented or held off during the flyback period until the ramp generator has fully returned to its quiescent state. When a trigger pulse switches the timebase bistable, TR419/TR420, the collector potential of TR419 goes positive and, acting through R448, turns TR437 on, presenting a low impedance path to ground to inhibit trigger pulses through C420. The capacitor, C_{HO} (representing the next smallest timing capacitor in the timing series Ct) is charged negatively by the negative-going ramp on the emitter of TR432, via gate, TR423/D425/D426. TR423 is only turned on by the timebase bistable during the sweep, via R481, and ensures that C_{HO} starts to charge immediately the ramp is initiated.

As C_{HO} charges negative, TR418 is cut off and the current in R466 flows through D442 as a second source to cause TR417 to conduct. At the end of sweep when the timebase bistable is reset, the collector of TR422 returns to ground, cutting off D440, and TR423 is cut off removing the charging current from C_{HO}. Current through R468 slowly discharges C_{HO}.

While the sweep generator is in its flyback period, C_{HO} holds TR418 cut off, leaving TR417 in conduction to inhibit trigger pulses into the timebase bistable. After the ramp generator has reached its quiescent condition, C_{HO} discharges sufficiently to allow TR418 to conduct and cut off TR417, allowing D421 to conduct on the next trigger pulse to initiate another sweep.

4.15 SINGLE SWEEP

This part of the circuit is based in IC400, a quad gate TTL integrated circuit connected to form two bistables. Gates, a and b, form a bistable to store the arm signal from the single sweep switch, and gates, c and d, form a bistable which acts on the hold-off circuit of the 'A' timebase to prevent trigger. When the single sweep switch is moved from NORMAL to SINGLE SWEEP, S44a grounds input 5 of IC400b. As R517 holds input 10 high, the bistable settles with 8 low and 6 high. The switch, S44b, removes the positive potential from R533 allowing R530 to turn off TR418 via D424, simulating the hold-off signal (see section 4.14) to inhibit trigger pulses. When the switch is moved to ARM position, S44a grounds input 10 and the state of bistable, IC400a/IC400b, is reversed. As output 6 goes low, this negative transition is coupled through C437 and D427 to input 2 of the second bistable. This switches over and input 3 goes high, cutting off D424 and removing the hold-off condition. Then a trigger pulse is able to trigger the bistable and a normal sweep is executed. At the end of sweep, the timebase bistable resets, generating a negative-going pulse on the emitter of TR430 which is coupled to input 12 by C436 and resets the second bistable. Output 3 goes low again, turning on D424, to reinstate the hold-off and prevent further sweeps. When the single sweep switch is returned to the SINGLE SWEEP position, before, during or after the sweep, the first bistable is reset, ready for the cycle to be initiated again after the sweep is complete. The action of this bistable avoids possible multiple triggering due to contact bounce of S44A since this switch must re-make to the SINGLE SWEEP position before the ARM condition of the bistable is removed. TR443 controls the neon indicator lamp, N400, to indicate the state of the second bistable.

4.16 COMPARATOR AND "B" SINGLE TRACE BISTABLE

TR615, TR616, TR614 and TR617 form the comparator which operates on the "A" ramp to define the delay period. Assuming D608 is cut off, (TR620 on) the comparator functions as follows:– The bases of the long-tailed pair, TR614 and TR617, are driven from the "A" ramp and the delay potentiometer, respectively. R745 ensures that the starting potential of the "A" ramp is more positive than that on the wiper of the delay multiplier potentiometer. Thus current initially flows more in TR614 rather than in TR617, biasing the second long-tailed pair, TR615/TR616, with TR615 on and TR616 off. The collector current of TR615 biases D633 into conduction to present a low impedance to "B" trigger pulses applied through C620, and prevents the triggering of the "B" timebase bistable, TR612/TR613.

At the point in the "A" sweep determined by the setting of the delay control potentiometer, R744, the base of TR614 becomes more negative than that of TR617, and so the bias on the input of the pair, TR615/TR616, is reversed, and TR615 is turned off. This removes the current through D633, and allows the reset trigger pulse through C620 to trigger the "B" timebase bistable. Alternatively, if S71 is closed for 'B starts after delay', the bias of R663 acts as a trigger pulse to start the "B" sweep immediately. TR620 and TR621 form the "B" timebase single trace bistable. In the 'A only' position, R699 is pulled negative so that D612 is cut off. The collector potential of TR621 is near zero, TR620 is turned off, and current flows through R691 (the comparator) such that TR615 remains on, independent of the state of TR614 and TR617. This stops the "B" timebase bistable triggering in the 'A only' condition.

In all but the 'A only' position of the display switch the collector resistor of TR621, R699, is connected to approx. +15V and the bistable can function.

At the start of the "A" sweep, a negative pulse from the "A" timebase bistable (B enable) is applied through C630, turning off TR621 and turning on TR620, to reverse bias D608 and allow the comparator to operate. When the "B" timebase bistable is triggered, the collector of TR613 goes negative and this transition is coupled via R676 and diode D611, to turn off TR620, resetting the "B" single trace bistable. D608 again conducts to override the comparator action and so inhibit further triggering of the "B" timebase.

4.17 "B" TRIGGER AND RAMP GENERATION

The "B" trigger amplifier, Schmitt trigger, timebase bistable and ramp generator are very similar to their "A"

timebase counterparts. The following description is brief and reference to the equivalent component in the "A" circuit is shown in brackets.

The "B" trigger source is selected by S70 from CH1, CH2 composite or LINE which are each common to the "A" and "B" time-bases. The "B" ext. trigger is separate and is derived from the attenuator of approximately 50:1 consisting of R614, R615, C601 and C602. The selected signal is taken to emitter-followers, TR605 and TR606 (TR409 and TR410), and then to the long-tailed pair, TR607/TR608 (TR413/TR414) via the polarity switch, S70d and S70c. The level potentiometer, R631 (R440), determines the potential on the undriven side of this amplifier. The amplified signal is taken to the second long-tailed pair, TR609/TR610 (TR415/TR416). The output of this amplifier drives direct to the Schmitt trigger, TR601 and TR602 (TR401 and TR402).

The trigger pulses generated by the Schmitt trigger are coupled via C620 and D604 to the base of TR612 (TR419) which together with TR613 (TR420), forms the "B" time-base bistable. The action of the comparator in gating trigger signals into the bistable is already described in section 4.16.

A trigger pulse allowed through the gate turns off TR612 and TR613 on. The 'B' ramp generator will now run until the negative-going ramp on the emitter of TR629, pulls the base of TR613 negative through D610, when the bistable will be reset. TR618 and TR619 (TR421 and TR422) generate the "B" bright-up current, and the "B" gate output signal respectively. TR611 will reset the "B" bistable at the end of the "A" sweep if this occurs before the "B" ramp has reached its normal amplitude.

The "B" gate output transistor, TR422, also provides the "B ends A" pulse which is used in the mixed mode, and is taken via C632 to a gate, D630/D632/R659/R739, and from there to the A timebase (see Mixed mode). In the "A intensified by B" and the "B" modes the "B" ramp generator operates in a manner similar to the "A" ramp generator current through R719, turns on gate, D620/D618, and effectively connects the emitter of TR631 (TR429) to ground.

The source-follower, TR622 (TR426), is not half of a matched pair of F.E.T's in this case, but has a simple current source, TR623 (TR425), as a very high impedance load. The emitter-followers, TR627 and TR629 (TR427, TR428), are connected directly to TR631 (TR429). TR628 (TR431) provides the flyback current. The "B" ramp is taken from the emitter of TR629 via the gate, D625 and D626.

In normal operation the "B" ramp will be reset at the end of a sweep so that in the quiescent state, TR631 is operating as an amplifier transistor, part of the negative feedback loop, TR631, TR628, TR622, TR627 and TR629. In the mixed mode, the gate (D620 and D621) connecting the emitter of TR631 to ground, is turned off, and the gate, D619 and D624, is closed to connect its emitter to the "A" ramp output voltage. In the reset state of the "B" ramp generator, as the "A" ramp voltage goes negative, the feedback loop will make the "B" ramp follow. When the "B" sweep starts, the feedback loop is broken as TR628 is turned off, and the "B" ramp runs normally but starting from the "A" ramp level.

4.18 THE BRIGHT-UP AMPLIFIER

The Bright-up amplifier which controls the Z modulation of the C.R.T. consists of an inverting amplifier, TR970, TR971 and TR972, with shunt feedback applied through R977, the base of TR970 being a virtual earth point. The inputs include current pulses from the "A" and "B" timebase bistables, (TR421, TR618 respectively), chop blanking current pulses from TR218, and external Z modulation current waveforms (from emitter-follower, TR903, and R974), a d.c. current derived from the INTENSITY control, R60, through R970, and a bias current through R971, obtained from the timebase DISPLAY switch circuit and the CONTRAST control. The instantaneous sum of these input currents is balanced by the feedback current from the output through R977, so that the output voltage waveform follows the sum of the input currents.

The operating levels in the various display modes are tabulated overleaf.

The mixed mode follows the "A intensified by B" bright-up condition. The Intensity control current and the Ext. Z modulation current are added through D970, the maximum intensity condition being when the current in D970 is zero, and the blanked condition being when the current in D970 is +2mA.

During the chop blanking period, a further +2mA current pulse is added which makes total applied input current $\geqslant$+2mA, and blanks the trace for all settings of the intensity control.

The maximum output from the amplifier is approximately 25 volts, corresponding to this 2mA change in input current. The diode, D971, ensures that when the amplifier is overloaded by a negative input, the "A" and "B" bright-up inputs do not move far from their normal working voltage.

Diodes, D974 and D975, ensure that TR972 does not bottom. TR971 provides essentially a high impedance constant current load for TR972 but C974 causes it to act as a complementary amplifier with TR972, to provide a low output impedance at high frequencies to drive the mainly capacitive load.

The output of the amplifier is connected via C979 directly to the grid of the C.R.T, and through R982 to the low voltage side of the floating grid supply. The dc voltage with respect to ground applied to the grid is then determined by the potentiometer, R988, (to allow for variations in grid cutoff between C.R.T's), resistor, R987 across the grid supply and the voltage on the output of the amplifier.

Display Mode	Condition	Input Current				Total Current in D204	Intensity Control Range
		Bright-up		Bias			
		'A'	'B'	Contrast MAX.	Contrast MIN.		
EXT X		+2mA	+2mA	-4mA	-4mA	0	Full Inten to Blanked
'A'	Waiting	+2	+2	2	−2	+2	Blanked
	running	0	+2	−2	−2	0	Full Inten to Blanked
	'A'&'B' Waiting	+2	+2	0	−2	+4/+2	Blanked
'A' intens by 'B'	'A' running	0	+2	0	−2	+2/0	From Inten set by CONTRAST to Blanked
	'B' running	0	0	0	−2	0/0*	Full Inten to Blanked
	'A'&'B' Waiting	+2	+2	0	0	+4	Blanked
'B'	'A' running	0	+2	0	0	+2	Blanked
	'B' running	0	0	0	0	0	Full Inten to Blanked

*D970 prevents reversal to −2mA.

The time constant, C979/R989, is much longer than the time constant, C980/R982, so that a voltage step of say +25V at the output of the amplifier is coupled to the grid and held by C979 and R989, while C980 rapidly charges through R982, causing the floating grid supply to rise by +25V. This causes the voltage across R988 to be reduced to zero before C979 can discharge significantly, preventing any further change in grid potential. Any voltage change on the output of the amplifier is faithfully reproduced on the grid by this means. The neons, N971 and N972, protect the C.R.T. from excessive grid-to-cathode voltage on switch-on or switch-off.

EXT. Z MODULATION

R913, R914, R915 and R916 form an attenuator and dc shift circuit for Ext. Z modulation signals. D902 and D901 are protection diodes. R974 defines an input current to the bright-up amplifier from emitter-follower, TR903. The voltage gain from the Z mod input socket to the output of the bright-up amplifier is approximately unity and high frequency signals are connected via C977, R985 and C978 to the C.R.T. cathode, so that the bandwidth of the Ext.Z modulation is not limited by the bandwidth of the bright-up amplifier.

4.19 X GATE AND X OUTPUT STAGE

The input of the X output amplifier can be connected to either "A" or "B" ramp outputs, or the output of the External X amplifier as determined by the Display switch, S50, and the "A" timebase range switch, S43. This switching is performed by diode gates, D432/D433 and D625/D626 for the "A" and "B" ramps respectively and by D603 for the External X amplifier.

When External X is selected on the "A" timebase range switch, −15V is applied via R549 and R742 to the "A" and "B" gates respectively, cutting off both, irrespective of the position of S50. Simultaneously +15V is applied to the External X amplifier supply rail, bringing its output (emitter TR604) to approximately +2V. With the "A" and "B" gates off, current flows from R651 through D603 to the emitter of TR604, thus connecting this point to the input of the X amplifier, PLB12.

With the "A" timebase range switch in any position other than Ext. X, S50 determines which ramp gate functions by applying either a negative voltage (off) or +15V (on) to R549 or R742. The Ext. X amplifier and gate are disabled by the removal of +15V from its supply line. In the positions "A" and "A intensified by B" the "A" gate is turned on and "B" gate turned off. In the "B" position and "A and B Mixed" position, the "A" gate is turned off and "B" gate turned on.

The X output amplifier consists of a long-tailed input pair (TR921 and TR929) driven from the current source, TR923. The inputs to the amplifier are the selected ramp/Ext X signal to the base of TR921 and the shift voltage to TR929. The output from this pair feeds via the emitter followers, TR922 and TR928, into the differential cascode output stage. There is overall shunt feedback to set the gain and stabilise the working conditions through resistors R923

and R949. The gain of the amplifier is set by the network, R927 and the preset R933, in the x1 mode. In the x10 mode the relay, RL921, is energised and contacts bring R938 and preset R943 into circuit.

4.20 EXTERNAL X AMPLIFIER

The circuit for the external X amplifier is included on the 'B' timebase circuit Fig. 6. The external input signal is applied to the base of the amplifier transistor, TR603, through the capacitor/resistor network, C606/R619. The trimmer, C645, is used to set the H.F. response. The diode, D600, protects the base-emitter junction of the transistor against excessive reverse voltage. Resistors, R618 and R620, together with R619 set the quiescent base voltage of the input transistor. Capacitor, C607, provides some HF peaking. The collector voltage swing is passed via emitter-follower, TR604, through diode, D603, (if enabled) to the X amplifier. Only when External X is selected, is the +15 volt line connected via the 'A' timebase range switch to enable the amplifier.

4.21 RAMP AND GATE OUTPUTS

THE 'A' RAMP OUTPUT

Mounted on the interconnect printed circuit board is the inverting buffer amplifier connected to the 'A' ramp via PLA1 of SKA. The 'A' ramp, running from near zero to approximately −4V, is connected directly to the base of TR951. This transistor is biased on by emitter resistors, R953 and R952. A positive-going ramp (0V to +10V) is generated across the collector load, R951, and is taken, via R954, to the output socket, (SKJ).

THE 'A' GATE OUTPUT

This signal is taken from the collector of TR422 in the 'A' timebase. The transistor is driven from the timebase bistable and gives a positive output pulse while the 'A' ramp is running. The pulse is taken through R503 and PLA4 of SKA to the rear panel, SKK.

THE 'B' GATE OUTPUT

This output is taken from the collector of TR619 in the 'B' timebase. The transistor is driven from the timebase bistable and gives a positive output pulse while the 'B' ramp is running. The pulse is taken through R684 and PLB3 of SKB to the rear panel, SKL.

4.22 CALIBRATOR

The circuit diagram for the calibrator is included on the 'B' timebase circuit, Fig. 6.

The components forming this circuit are mounted on the 'B' timebase P.C. assy. The circuit consists of an emitter-coupled oscillator, TR624 and TR625, with C634 as the timing capacitor.

The collector current through TR625 is used to turn TR626 on and off to give a square wave output across R760 and R732. This is set to be 1 Volt peak to peak by R730.

The values of the resistors in the dividing chain are selected such that the output resistance is 1KΩ, giving a 1mA calibrator current if the output is shorted.

4.23 THE POWER SUPPLIES

The OS3300A basically operates from positive and negative 15V lines and a +120V line, each stabilised and independently protected against overload. The E.H.T. lines are all obtained from a high frequency oscillator with overload protection but with direct stabilisation only on the −1.25kV CRT cathode supply. This oscillator is supplied from the +20V unstabilised line used for the +15V line.

All supplies are obtained from transformer, T83, via the range selector switch, S81, the supply fuse, FS83, and supply on/off switch, S80.

One secondary from T83 is the 6.3V supply to the CRT heater and another the low voltage (approx. .25 Volt) for the line trigger signal. This latter voltage passes via SKB – PLB19 and PLB20 to the trigger selector switches. The three remaining secondaries are rectified and smoothed as follows.

4.23.1 +15V, −15V and +120V LINES

One secondary from T83 feeds the bridge rectifier, MR83, and develops approximately 20V across capacitor, C85. This is used to obtain a stable, overload protected, −15 Volt line using an integrated circuit regulator, IC801, which contains a reference, comparator input amplifier and output current amplifier. In addition it includes the overload protection circuitry to operate from the voltage developed across the current sensing resistor, R836. The output from this IC regulator drives the external series regulator, TR838.

The output of the line is set to be −15V by the preset potentiometer, R838. Components, R855 and C831, reduce the noise present on the internal reference and C832 gives feedback compensation to prevent oscillation.

A similar secondary from T83 is rectified by MR82 and develops approximately +20V across C84. Protected by FS832 this +20V supply feeds the EHT oscillator. The voltage across C84 is also used to obtain the stabilised +15 volt line.

TR833, TR834, TR835 and TR837 form the +15V stabiliser circuit, which is referenced to the −15V line. If the +15V line is not at the correct potential, the junction of the two equal resistors, R847 and R848, will not be at 0V. The resultant differential voltage between the bases of TR833 and TR834 will modify the collector current of TR833 to drive through TR835 to the series regulator element, TR837, and so correct the line potential.

Excessive current drawn from the +15V line will develop a potential across R835 causing D833 to conduct in turn limiting the base current to TR835 and so also that in TR837.

Fuses FS833 and FS834 protect the +15 and −15 volt Lines respectively.

Protection diodes, D835 and D836, are normally reverse biased and only conduct in the accidental condition of a short circuit between the +15V and −15V lines.

Diode, D834, protects the base-emitter junctions of TR833 and TR834 against excessive reverse voltages. Cap-

acitors, C836 and C833, give h.f. roll-off to prevent oscillation; C835 reduces output ripple.

The secondary from T83 is rectified by MR81 and develops approximately 150V across C83.

R84 and C86 reduce the output line ripple. The +120 Volt line is referenced from the −15 Volt line by resistors, R842 and R843. Any error potential at the junction of these resistors drives the error amplifier, TR831, which in turn controls the series transistor, TR839. Transistor, TR832, protects TR839 from over voltage at switch on, or in the event of failure of the −15V line. If the junction of the potential divider, R840 and R841, goes too far negative, TR832 conducts allowing TR839 to conduct.

Short circuit protection on the 120V line is by means of the fuse, FS831.

4.23.2 E.H.T. SUPPLIES

The e.h.t. supply circuitry is as shown in Fig. 8. It comprises an oscillator driving a transformer with three secondaries, each rectified to provide the three lines of approximately −1330 volts, −1250 volts and +12kV, mounted within the EHT box assembly; and an error amplifier included on the Power Supply printed board.

The oscillator is formed by the centre tapped primary winding, of the transformer in the collectors of transistors, TR801 and TR802, with feedback windings taken to the bases via protection diodes, D801 and D802. The centre tap of the primary is taken through the choke, L801, to the supply and that of the feedback being returned to the supply through R801.

The waveform at the collectors is approximately alternate half waves of 55 volts amplitude at 30kHz.

The independent grid supply from one high voltage secondary winding is rectified, along with the cathode supply, within the module (part number 35301). One output from the cathode supply is used to stabilise the working of the e.h.t. oscillator by feedback current through the focus chain of R804 and R805, R82 (the focus control) and resistors, R806 to R809; to the error amplifier, where it is compared with the reference current obtained from the stabilised +15V line via resistors, R868 and 'set EHT' preset control R854. This difference current is applied to the base of TR841 (a long tailed amplifier) whose collector current controls TR842 and in turn TR843. TR843 acts as a series regulator on the oscillator supply line, maintaining it at approximately 14 volts.

Overload protection is provided when the voltage across R862 causes D837 to conduct, thereby reducing the drive into TR842. The output from TR843 is limited to approximately 600 mA and if this current is maintained the fuse FS832 will blow.

The third high voltage secondary winding is connected in series with the cathode winding to give approximately 3kV p-p ac into the four stage multiplier module (part number 35300). The resulting +12kV is used as the p.d.a. potential for the final anode of the c.r.t.

4.24 CATHODE RAY TUBE AND ITS INPUTS

The OS3300A employs a conventional mesh p.d.a. tube with a high efficiency aluminised screen.

The interconnection diagram fig.9 shows the necessary connections to the various electrodes.

THE GUN

An independent winding on the mains transformer drives the heater for the cathode. The beam current and hence the spot intensity is controlled by the differential potential between the grid and cathode. The −1.25kV cathode potential is the direct stabilised output from the e.h.t. oscillator. The grid potential is the sum of the floating grid supply from the e.h.t. oscillator and the output potential of the bright-up amplifier to which the grid supply is referred.

The c.r.t. beam is brought to a clear, well focussed spot by varying the potentials applied to the focus and astigmatism electrodes. These signals are derived from R82 (focus) and R81 (astigmatism) mounted on the front panel, the latter being a screwdriver adjustment. The focus electrode is normally variable over the range −730V to −840V and the astigmatism from +120V to 0V.

THE DEFLECTION SYSTEM

The Y plates are connected to the output of the Y amplifier and the differential signal applied, deflects the beam in the vertical direction. The mean plate potential is normally +60V and the sensitivity is approx. 3.9V/cm.

Similarly, the X plates are connected to the X output amplifier and the differential signal deflects the beam in the horizontal direction. The mean X plate potential is normally +65V and the sensitivity is approx. 12V/cm.

The deflection plate shield, S1, screens the deflection plates from the other electrodes and is held at a potential of +50V obtained from the junction of R919 and R920 on the interconnect p.c. board.

The interplate shield, S2, screens the X plates from the Y plates and is held at a potential 15V more negative than the X mean plate potential, derived from the wiper of R381 on the 'Y' output p.c. board.

Having passed through the deflection plate system the beam accelerates to the screen which is held at +12kV hg by an output from the e.h.t. oscillator, striking the phosphor at high velocity to produce the necessary bright trace.

THE TRACE ROTATION COIL

A coil, L83, fitted round the neck of crt, inside the magnetic shield is used to align the trace with the horizontal graticule lines.

The current for this coil is taken from the preset potentiometer, R850, through R849, on the power supply board.

4.25 SCALE ILLUMINATION

The external scale is illuminated by two lamps, ILP83 and ILP84.

The supply for these lamps is derived from the emitter-

follower, TR836, on the power supply board; being set by the scale illumination potentiometer, R80, on the front panel.

Both the emitter-follower and the control potentiometer are supplied from the full-wave rectified signal taken from the transformer at the junction of diodes, D83 and D84.

4.26 THE BEAM FINDER

Operation of the TRACE LOCATE push button performs the following functions. Firstly, R85 is connected in a series with the +120 volt line that feeds the X and Y plate amplifiers. This limits the swing to approximately 8cm. in the X direction and 12cm in the Y. To further limit the scan in the Y direction to 6cm, the current in the output stage is reduced by switching R366 in series with the normal emitter resistor of the current source transistor, TR355.

The Bright-Up amplifier is biased by resistors, R973 from the −15V line and R993 from the switched +120V line. The values are so arranged that 2mA flows into the amplifier input from the negative supply, allowing normal operation of the INTENSITY control. When the TRACE LOCATE button is pressed this bias current is changed due to the voltage across R993 falling to 70V, thereby increasing the negative bias to approximately 4mA which gives full bright up to the display, over riding the setting of the INTENSITY control.

5.1 GENERAL

The instrument is electrically protected by five fuses as follows:–

1. 1A 'Slo-blo' Size 20mm (FS80 Pt.No.34790) in the supply input and mounted on the rear panel.
2. 250mA Size 20mm (FS831 Pt.No.32338) in +120V supply line and mounted on the Power Supply board.
3. 500mA Size 20mm (FS832 Pt.No.32339) in the +20V line supplying the E.H.T. Oscillator also mounted on the Power Supply board.
4. 1A Size 20mm (FS833 Pt.No.52162) in the +15V line and mounted on the Power Supply board.
5. 1A Size 20mm (FS834 Pt.No.52162) in the –15V line and mounted on the Power Supply board.

Access to the four latter fuses is by removal of the bottom cover.

The following sections give information allowing access to and removal of the various printed circuit boards and assemblies as may be found necessary, during fault finding procedures.

If, during fault finding a component needs replacing, it should be cut from the printed circuit board as close as possible to the component, leaving the wires connected to the copper track and protruding through to the component side of the board. The new component should then be soldered into position by attaching it to these protruding wires. This protects the copper track from damage.

If a fault on a printed circuit board cannot be cleared, it is recommended that the instrument is returned to the manufacturer for repair. When faults have been cleared it is recommended that the calibration procedure is implemented to ensure that the instrument conforms to the specification.

5.2 ACCESS

Figures 14, 15, 16 and 17 illustrate various views of the instrument showing access to the majority of preset components when the top and bottom covers have been removed. Each cover is retained in position by four latch fasteners. Each fastener is released by turning it one quarter of a turn clockwise or counter-clockwise.

The construction of the instrument has been arranged so that individual boards and assemblies can be checked and components changed without actually removing the assemblies from the main frame or disconnection of cable forms. In the case of the Time Base unit this has been achieved by making it a plug-in assembly which can be removed and operated on an extension lead, PL91. This assembly is then still fully functional and access is provided to both sides of both printed circuit boards.

The following description details the method for removing the individual assemblies:–

5.2.1 ATTENUATOR AND PRE-AMPLIFIER ASSEMBLY

1. Each assembly is fitted with its own screening cover and it is only necessary to remove the cover from the unit requiring attention. The procedure is identical for both attenuator assemblies.
2. Having removed the screen, take out the shift control spindle by loosening the grub screws on the universal coupling, also remove the coupling.
3. Unsolder the three supply leads and four signal leads from the rear of the horizontal printed circuit board.
4. Remove the knob from the VOLTS/cm selector switch and its fixing nut, the lever switch knob and the fixing stud behind the front panel mounted between the BNC socket and the lever switch.
5. The unit can now be removed by lifting first from the rear to clear the shift control support bracket and pulling towards the rear of the instrument.
6. For fault finding, the unit may be operated out of the frame by extending the supply and signal leads. Providing that the signal leads are kept reasonably short, the complete channel may be checked at frequencies approaching the full bandwidth.

5.2.2 BEAM SWITCH & DELAY LINE EQUALISER BOARD

1. Disconnect the signal leads from the rear of the board (Pins 43 & 44) and remove the seven fixing screws.
2. Release the Delay Line from its retaining clips.
3. The board may now be brought carefully to the upright position without unsoldering any further connections. This operation then gives access to both sides of the board.
4. If it is required to operate the board in this position, it is recommended that the output should be reconnected via extended leads.
5. Raising this board also gives access to the SHIFT control potentiometers, the x5 GAIN pull switches and the CH2 INVERT switch.

5.2.3 DELAY LINE

1. The Delay Line is mounted above the shield, by means of clips through the top of C.R.T. shield.

5.2.4 OUTPUT BOARD

1. Remove the two Y Plate leads and the S2 connection from the tube side pins.
2. Remove the board fixing screws and also the screws attaching the output transistor heat sink to the tube support assembly.
3. The board, together with the output transistors, may now be swung out of the frame on the connecting leads giving access to both sides of the board.
4. The output transistors can be changed without removing the board by taking out the three fixing screws and lifting off the paxolin clamp.

5.2.5 TIME BASE UNIT

1. Remove the fixing screws from the Time Base section of the front panel and also slacken the two fixing screws attaching the rear of the unit to the cross bar (see fig.2).
2. Carefully draw the Time Base Unit through the front of the instrument, taking care not to catch any components on the front extrusion.
3. Check that the polarising keys are still correctly positioned in the multiway connectors.
4. Both Time Base Boards are now accessible and the unit may be operated on the extension lead, PL91.

5.2.6. BRIGHT-UP AMP AND X AMP BOARD

1. Remove the two X plate leads from the c.r.t.
2. Withdraw the printed board backwards to clear the P.C. connector and then lift upwards. Full access is then given to both sides of the board.

5.2.7 POWER SUPPLY ASSEMBLY

The low voltage power supply unit is on a removable sub-chassis mounted in the rear of the instrument.

1. Remove the screws securing the moulded rear cover, and remove the cover.
2. Remove the remaining screws holding the unit on to the rear extrusion and the screws supporting the Interconnect support bar and the Delay/Beam Switch printed circuit.
3. Remove the four screws, XX and YY, in the rear cross bar (See fig. 13)
4. The unit may now be removed from the frame as shown in fig.12,to the distance provided by the loop in the cable form.
5. Access is now provided to the mains transformer and VOLTAGE SELECTOR switch, smoothing capacitors and series stabiliser transistors.

5.2.8 POWER SUPPLY PRINTED CIRCUIT BOARD

1. Remove the board fixing screws and the heatsink bracket screws.
2. The board will now lift into the vertical position on its cable form giving access to both sides.

5.2.9 INTERCONNECT BOARD

Access to this board may be obtained by removing a number of units as previously described, namely:– Time Base Unit, Bright-Up Amplifier and Power Supply Assembly.

5.2.10 E.H.T. UNIT

1. Remove the two screws at the top of the box, which pass through the box and into the centre bar of the instrument.
2. Lift the box out of the instrument on its cable form.
3. Remove the six screws which hold the lid and remove. Insert one of the long fixing screws through its original hole in the rear of the box and screw into the threaded insert provided in the centre bar of the instrument. This secures the unit for servicing purposes.
4. The oscillator printed circuit board and transformer are now accessible. The printed circuit board may be slid out on its runners to provide access to both sides.

5.2.11 CATHODE RAY TUBE

1. Access to the base of the tube is possible by removing the moulded cover which is attached to the rear of the instrument.
2. The tube may be removed by withdrawing from the front after taking off the escutcheon and filter assembly.
3. Before attempting to extract the tube, remove the side pin connectors and the base. It will also be necessary to unsolder the twist coil leads from the interconnection printed circuit board (pins TWIST & 0V). The twist coil is attached to the tube and therefore its leads should be fed through the hole in the shield as the tube is pulled forward.
4. Care should be taken when removing the tube not to bend the side pins as this may crack the glass around the seal.

5.3 FAULT FINDING TABLES

Faults may be localised by reference to the Fault Localisation information presented in fig. 18 and the Circuit Voltages listed in Section 5.4. which should be used as a general guide of voltage obtainable at certain locations within the instrument and can be used as an aid to servicing.

The power supply input voltage should be approximately at the mid range of the Supply Voltage setting. The power supply voltages in the tables are those appearing under these conditions. Other voltages assume that the Y inputs are grounded and the amplifiers are set to 5mV/cm sensitivity. The Time Base is set to FREE RUN, CH1 Mode with CH1 trace brought to the centre of the screen.

5.4 OPERATING POTENTIALS

(a) INPUT ATTENUATOR AND PRE-AMPLIFIER

Location		Voltage
TR102	Drain	Approx. 0V
TR103 and TR104	Collectors	13.5V
TR103 and TR104	Emitters	+0.7 to +2.7V
TR121 and TR122	Collectors	+4V
TR120	Collector	–5.5V
TR123 and TR124	Collectors	+6.6V
TR125 and TR126	Bases	+8.6V
"Trig" output		+7.9V
"Sig" output		+7.6V

(b) BEAM SWITCH AND DELAY LINE EQUALISATION

Location		Voltage
TR201,202,207 and 208	Emitters	+8.6V
TR202,208 and 220	Collectors	Nominally 0V
TR207	Collector	+0.8V
TR203,204,205 and 206	Collectors	+5.4V
TR209	Collector	+2.5V
TR209	Base	+0.8V
Y2 O/P		Nominally 0V
TR210 and TR211	Collectors	+6.3V
TR214	Collector	+7.4V
Pin 31 and 33		+5V
TR215	Collector (CH1 Selected)	+2V
TR215	Collector (CH2 Selected)	+7V
TR217	Collector	+13.7V
TR218	Collector	+2.8V
TR219 and TR220	Emitters	+6.8V
TR300 and TR301	Emitters	+4.1V
TR300 and TR301	Collectors	–1.4V
TR302 and TR303	Collectors	–2.3V
TR304 and TR305	Collectors	+3.8V
Pins 43 and 44		+2.4V

(c) Y OUTPUT AMPLIFIER

Location		Voltage
TR356 and TR357	Collectors	+9.5V
TR351 and TR352	Collectors	+12.5V
TR355	Collector	+6.7V
TR353 and TR354	Collectors	+60V
Pin S2		Approx+10V

(d) X OUTPUT AMPLIFIER AND INTERCONNECT

Location		Voltage
TR921 and TR929	Collectors	+8.3V
TR924 and TR925	Collectors	+9.5V
TR926 and TR927	Collectors	+65V

(e) BRIGHT-UP AMPLIFIER

Location		Voltage
TR903	Emitter	+1.2V
TR972	Collector (Ext X Mode, Max Inten)	+40V
Vg. Hi		−1330V
Vk		−1250V

(f) E.H.T. SUPPLY

Location		Voltage
TR843	Collector	+20V
TR843	Emitter	+15V
PDA	Connector	+12kV

(g) LOW VOLTAGE POWER SUPPLY

Location		Voltage
TR837	Collector	+20V
TR835	Collector	+15.5V
TR833	Collector	−0.65V
TR839	Emitter	−18V
TR836	Collector	+15V
TR838	Collector	+8.5V

(h) TIMEBASES

Operating potentials and waveforms within the timebase unit are shown in figs. 12 and 13.

SINGLE SWEEP I.C.

	I.C. Pin No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Lever position	Arm	0	2.5V	3.6	4.4	4.8	0	0	4.4	0	0	0	2.5	0	5
	Single Sweep(Armed)	0	2.5V	3.6	0	0	4.4	0	0	4.4	4.8	0	2.5	0	5
	Single Sweep (Fined)	3.8V	2.6	0	0	0	4.4	0	0	4.4	4.8	3.8	2.5	0	5

5.5 CALIBRATION PROCEDURE

5.5.1 TEST EQUIPMENT

1. Variable autotransformer. Output voltage 95 to 260V at 1A with ac rms voltmeter. (Variac).
2. Multimeter. 0-2.5kV with at least 20,000 ohms/volt sensitivity. Accuracy within 2%
3. Voltage Calibrator. 1kHz squarewave generator with amplitude 5mV to 100V. Accuracy within 1%.
4. Time Mark Generator. Marker generator of 0.1μs to 1 sec. Accuracy within 1%.
5. Squarewave Generator. 1MHz flat top square wave generator with adjustable amplitude 0.1V to 1V into 50 ohms having a rise time of less than 2ns.
6. R.F. Sinewave generator. 500kHz to 60MHz with 50kHz reference frequency. Output amplitude 25mV to 5V p-p into 50 ohms. Amplitude accuracy at 50kHz and 500 kHz to 60MHz within 3%.
7. LF SineWave Generator.
8. Capacitance Standardiser. 1MΩ/28pF, BNC 50Ω termination, BNC-BNC connector lead (PL43), Time Base Extension Lead PL91.
9. E.H.T. Meter 0-12kV.

NOTE Calibration should be carried out at normal ambient temperature and should not be commenced until the instrument has been operating for at least 15 mins.

5.5.2 SET SUPPLY RAIL VOLTAGE

1. Set the INTEN. control to minimum.
2. Set the SUPPLY VOLTAGE switch on the rear panel to suit the supply. Apply the supply voltage via the Variac set to mid range of the Supply Voltage setting.
3. Check that the SCALE control varies the scale intensity and that the neon, N80, is energised.
4. Connect the multirange meter between chassis and pin '−15V' on the Power Supply printed circuit board. Adjust the voltage to −15V ±2% by means of R838.
5. Check that the voltage to chassis on the following pins on the Power Supply printed circuit board, are within the following limits,

   '+15V' +15 ±4%
   +150V +150V ±4%
6. Set the multirange meter to read 2500V and meter between chassis and pin 'VK' on Bright-Up Amplifier printed circuit board. Adjust R854 on Power Supply printed circuit board for a reading of −1250V.
7. Check that e.h.t. supply at tube cavity cap connector is 12kV ±0.5kV.

5.5.3 SET TUBE CUT-OFF AND VISIBLE DELAY

Due to small changes in the c.r.t. control grid characteristics during warming up, the first part of the adjustment should be made as soon as a trace appears after switch-on.
Advance BRIGHTNESS Control to the '9 o'clock' position. Adjust R988 on Bright-Up Amplifier printed circuit board so that the trace is just not visible.
Set the TIME BASE controls to give a sweep rate of 20ns/cm. Inject the 1MHz fast rise pulse and adjust trigger so that the leading edge is visible.

5.5.4 Z MODULATION

1. Apply a 1KHz square wave of 5V amplitude to the Z MOD socket on the rear panel and to CH1 INPUT socket with CH1 VOLTS/cm switch set to 2V
2. Obtain a stable trace and check that the modulation is just visible.
3. Increase input to 20V p-p, check that the trace can be fully blanked and that positive signals cut off and negative signals brighten up the trace.

5.5.5 X AMPLIFIER ADJUSTMENTS

These adjustments should be carried out with the TB unit on an extension lead, PL91, to give access to controls.

1. Set "A" TIME/cm to EXT X and VARI TIME/cm control to CALIBRATED.
2. Inject a 10V p-p 1kHz square wave into the EXT X socket.
3. Adjust R933 on X Amplifier and Bright-Up printed circuit board, to give 10cm of X deflection.
4. Pull the Fine X Shift (x10 Amp gain).
5. Inject a 1V p-p 1kHz square wave into the EXT X socket.
6. Adjust R943 on X Amplifier and Bright-Up printed circuit board to give 10cm of X deflection. Switch back to x1 x amp gain.
7. Inject an 8V p-p 10kHz square wave into the EXT X socket. Adjust C645 (Time Base 'B' printed circuit board) to remove any 'tail' which extends beyond the bright spots at the extremes of the deflection.

5.5.6 TIME BASE ACCURACY ADJUSTMENT

These adjustments should be carried out with the Time Base operating on an extension lead, PL91, to give access to the appropriate controls.

A Time Base:–

1. Set "A" TIME/cm to 1mS/cm, VARIABLE TIME/cm Control to Calibrated.
2. Inject 1kHz marker pulses into CH1 channel and trigger for a stable trace.
3. Adjust R510 on 'A' Time Base printed circuit board for 1 marker pulse per cm.
4. Set Time Base Range Switch to 0.1μs/cm, VARIABLE TIME/cm Control to Calibrated.
5. Inject 10MHz marker pulses into CH1 channel and trigger for a stable trace.
6. Adjust C535 on 'A' Time Base printed circuit board for 1 marker pulse per cm.
7. Check that 'A' TIME/cm VARIABLE gives greater than 3:1 reduction in speed.

B Time Base:–

The procedure should be repeated for the 'B' Time Base, adjusting R708 at 1kHz and C631 at 10MHz. These controls are situated on the 'B' Time Base printed circuit board.

5.5.7 TRIGGER LEVEL SLOPE BALANCE ADJUSTMENT

Adjustment to be carried out with Time Base on Extension lead, PL91.

A Time Base

1. Inject a 1kHz sine wave into CH1 and set TRIGGER LEVEL control to mid-position, TRIGGER COUPLING in AC position.
2. Adjust R453 ("Slope Bal") so that there is no significant movement of the trigger point when the TRIGGER SELECT Switch is moved from "+ve to –ve".
3. Move TRIGGER COUPLING to DC position and adjust R213 to obtain the same trigger point. Repeat using CH2 channel and R223.

NOTE R213 and R223 are situated on the Delay Drive/ Beam Switch Printed Circuit Board Assembly.

B Time Base

The above procedure should be repeated for the 'B' Time Base adjusting R643 to give the desired effect.

5.5.8 COMPOSITE TRIGGER BALANCE

1. Apply a 1kHz sine wave to CH1 INPUT to give an amplitude of 6cm.
2. Set the TRIGGER LEVEL control to give triggering from a mid point on the sine waveform with the TRIGGER COUPLING set to DC and the TRIGGER SELECT switch to CH1 + slope.
3. Reset the TRIGGER SELECT switch to COMP + slope and and adjust R297 on the Delay Drive/Beam Switch printed board to give the same trigger point as in 2.

5.5.9 INTERNAL 1V and 0.1V CAL ADJUSTMENT

Adjustment to be carried out with Time Base on Extension lead PL91.

1. Inject 1V p-p 1kHz square wave into CH1 channel from external calibrator. Set CH1 VOLTS/cm to 0.1V and adjust VARIABLE GAIN Control to give exactly 8cm deflection.
2. Substitute internal cal. waveform for signal from external calibrator and adjust R730 to give exactly 8cm deflection.
3. Inject 100mV p-p 1kHz square wave into CH1 channel form an external calibrator. Set CH1 VOLTS/cm to 10mV and adjust the VARIABLE GAIN Control to give exactly 8cm deflection.
4. Substitute 0.1V from the internal calibrator into the Y1 input. Check that the display is 8cm ± 1%.

5.5.10 CHANNEL 1 & 2 FINE GAIN CONTROL BALANCE

1. Set CH1 VOLTS/cm switch to 5mV, INPUT COUPLING Switch to GND, Mode switch to CH1, Time Base to Free Run.
2. Set trace on centre line by means of CH1 shift control. Adjust front panel BAL control to give no trace movement when the CH1 FINE GAIN Control is operated.
3. Repeat procedure for Channel 2.

5.5.11 CHANNEL 1 & 2 STEP ATTENUATOR BALANCE

1. Set CH1 VOLTS/cm switch to 20mV, INPUT COUPLING Switch to GND, Mode switch to CH1, Time Base to Free Run.
2. Set trace on centre line by means of CH1 SHIFT CONTROL. Adjust Step Bal (CH1) to give no trace movement when the VOLT/cm switch is moved to 5mV/cm.
3. Repeat procedure for Channel 2, adjusting Step Bal (CH2).

5.5.12 X5 GAIN BALANCE

1. Set CH1 VOLTS/cm switch to 5mV INPUT COUPLING Switch to GND, Mode switch to Y Time Base to Free Run.

2. Set trace on centre scale line by means of CH1 shift control. Adjust R146 (CH1) so that no trace shift occurs when the X5 pull switch is operated.
3. Repeat the procedure for Channel 2, adjusting R146 (CH2).

5.5.13 ADJUST TRACE ALIGNMENT

Set Time Base to 1ms/cm and TRIGGER SELECT to FREE RUN.

Adjust R850 (Trace rotation preset) to bring the trace parallel to the horizontal centre line.

5.5.14 GEOMETRY

Apply to CH1 INPUT a 1kHz sinewave to give an amplitude of 8cm, adjust ASTIG and FOCUS controls for a sharp display and set Time Base to display approximately 10 cycles. Adjust R351 (on the Y O/P Board) for a compromise between horizontal and vertical deflection to eliminate pincushion and barrel distortion. Reset ASTIG and FOCUS controls if necessary.

5.5.15 DELAY LINE MATCHING

1. Set CH1 VOLTS/cm switch to 20mV, inject 1MHz squarewave to give 6 cm deflection, adjust trigger to give stable trace.
2. Inspect top of waveform for any step occurring approximately 200μs after the start of the pulse.
3. If any step is present replace A.O.T. resistor, R265, with a small 220Ω carbon potentiometer on short leads, adjust for no step, measure required value and substitute fixed resistors of nearest preferred value.

5.5.16 'ADD MODE' AMPLIFIER BALANCE

1. Set FUNCTION SWITCH to CHOP and bring both traces to the centre horizontal line, by means of CH1 and CH2 SHIFT controls.
2. Set the MODE SWITCH to ADD and note the direction and amount of movement of the trace. Return to CHOP Mode.
3. Add 100kΩ potentiometer across a.o.t. position, R294 or R295, to give a direction of movement the same as that given when moving from CHOP to ADD.
4. Adjust potentiometer to bring both traces to position found in '2'.
5. Re-centre traces, switch to ADD, movement should now be less than 0.5 cm.
6. Replace potentiometer with fixed resistor of the nearest preferred value.

5.5.17 CHANNEL 1 and 2 GAIN ADJUSTMENT

1. Set CH1 VOLTS/cm switch to 20mV, INPUT COUPLING Switch to DC, FINE GAIN CONTROL to Cal.
2. Inject a 1kHz squarewave having an amplitude of 120mV into CH1, adjust R227 (Set Gain CH1) to a deflection of 6cms.
3. Switch to 10mV range, inject 60mV and adjust R138 (CH1) to give 6 cm deflection.
4. Switch to 5mV range, inject 30 mV and adjust R136 (CH1) to give 6 cm deflection.
5. While still on 5mV range, inject 6mV, pull for X5 gain and adjust R229 to give 6 cm deflection.
6. Switch to all other ranges and inject the appropriate signal to give 6 cm deflection. Check that all ranges are accurate to within ±3%.
7. Repeat the above procedure for Channel 2 the adjustments for the 20mV, 10mV, 5mV and 1mV ranges being respectively, R231, (Set Gain CH2) R138 (CH2), R136 (CH2) and R233.

5.5.18 CHANNEL 1 and 2 ATTENUATOR COMPENSATION

1. Ensure that the attenuator covers are correctly fitted and that the link across the universal coupling on the SHIFT control is continuous.
2. Set CH1 VOLTS/cm switch to 20mV, INPUT COUPLING switch to DC, Inject 200mV 1kHz squarewave via the 28pF/1MΩ standardiser. Trigger for stable trace.
3. Adjust input trimmer, C171 (CH1) for square corner.
4. Remove standardiser, switch VOLTS/cm to 0.2V, inject 1V squarewave and adjust x10 compensating trimmer, C167 (CH1), for square corner.
5. Inject 2V squarewave via standardiser and adjust x10 input trimmer, C165 (CH1), for square corner.
6. Remove standardiser, switch VOLTS/cm to 2V, inject 10V squarewave and adjust x100 compensating trimmer, C161 (CH1), for square corner.
7. Inject 20V squarewave via standardiser and adjust C100 input trimmer, C159 (CH1), for square corner.
8. Remove standardiser and check all attenuator ranges, applying the appropriate amplitude, to ensure all ranges give a square corner to the applied waveform and are accurate to within ±3%.
9. Repeat above for Channel 2 the component numbering is the same except for a suffix 'CH2'.

5.5.19 Y2 OUTPUT AMPLITUDE AND PHASE ADJUSTMENT

1. Set CH1 and CH2 INPUT VOLTS/cm switches to 0.1V. INPUT COUPLING Switches to DC. Link CH2 OUTPUT to CH1 INPUT. FUNCTION SWITCH to ALT. FINE GAIN CONTROL to CAL.
2. Inject 0.5V 1kHz squarewave into CH2 input, trigger for a stable trace.
3. Adjust R238 to give equal deflections on CH1 and CH2 (i.e. CH2 Output of 100mV/cm).
4. Remove CH2 OUTPUT link from CH1 INPUT and take to EXT X and PULLx10.
5. Apply a sine wave source to CH1 and CH2. Adjust input level to give a convenient size display which should be a 45° line at low frequencies.
6. With input frequency of 500kHz, adjust capacity (approx 15pF) C228 (a.o.t.) until ellipse just closes. (Max. phase shift 3°, dc – 500kHz).

5.5.20 Y AMPLIFIER OVERALL PULSE RESPONSE

1. Set CH1 and CH2 VOLTS/cm switch to 20mV, INPUT COUPLING Switch to DC. Ensure that the AOT R230 and R235 are initially not in circuit. FINE GAIN CONTROLS to CAL.
2. Select CH1 Mode and inject 100mV squarewave at 100kHz. Adjust R309 to give optimum flat top response.
3. Change input frequency to 1MHz. Adjust R311 to give a response having approximately 20% undershoot over the first 35-40ns.
4. Adjust C311 to improve the edge response without

affecting adjustment 3.
5. Adjust C322, R357 and C357 for optimum leading edge and corner with no overshoot or hook.
6. Connect a small carbon 1kΩ potentiometer on short leads across a.o.t. pins R230. Adjust potentiometer and C202 to remove undershoot left in adjustment 4 + 5 Replace potentiometer with fixed resistor.
7. Inject 1MHz signal into CH2 and repeat adjustment 6 to establish correct value of R235.
8. Adjust C211 to give improvement in, without increasing, overshoot over first 15μs.

5.5.21 5mV and 10mV HF COMPENSATION

1. Set CH1 and CH2 VOLTS/cm switch to 10mV, INPUT COUPLING SWITCH to DC, FINE GAIN CONTROL to CAL.
2. Select CH1 Mode and inject 50mV squarewave at 1MHz. Adjust C123 (CH1) to give a square corner.
3. Switch to 5mV/cm, inject 25mV and adjust C122 (CH1) to give a square corner.
4. Repeat 2 and 3 for CH2 input, adjusting C123 (CH2) and C122 (CH2) respectively.

5.5.22 BANDWIDTH

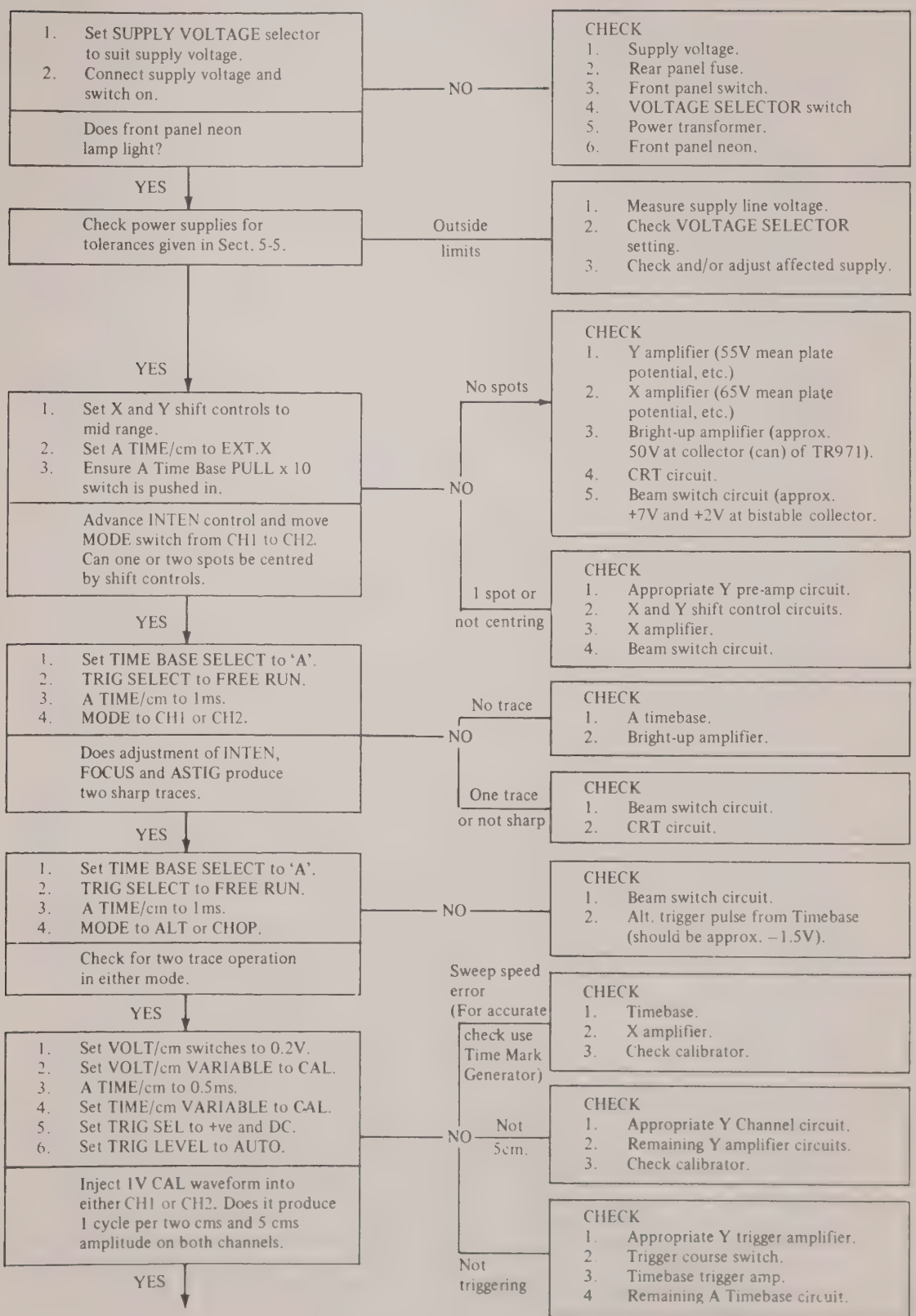
1. Set CH1 and CH2 VOLTS/cm switches to 20mV, INPUT COUPLING SWITCH to DC, FINE GAIN CONTROL to CAL.
2. Select CH1 Mode and inject 50KHz from Constant Amplitude Generator to give 5cm deflection. Increase the frequency of the generator until the display amplitude falls to 3.5cms. This frequency should be greater than 50MHz.
3. Repeat '2' for 10mV and 5mV positions on CH1 and for 20, 10, and 5mV positions on CH2.
4. Repeat to 1mV/cm (x5 gain) on both channels where the bandwidth should be greater than 10MHz.

5.5.23 CHOP WAVEFORM COMPENSATION

1. If any of the transistors or diodes associated with the beam switch are changed it may be necessary to re-adjust the capacitive balance of the circuit.
2. Set INPUT COUPLING SWITCH to GND, Couple A EXT TRIG via probe to the collector of TR218 (R283). Turn A TRIG SELECT to EXT.
3. Switch to CHOP Mode and set the two traces 0.5cm either side of the centre line by means of the SHIFT controls and adjust the Time Base (1μs/cm) so that individual chop transitions are visible.
4. Small amounts of capacity should be added between points 26 and 25 or 26 and 27 for CH1, and between 29 and 28 or 28 and 30 for CH2, to ensure that the chop transitions are flat and parallel to the centre line. The capacity required is usually small and is most easily achieved by using short lengths of enamelled copper wire twisted together.

TIMEBASE WAVEFORMS

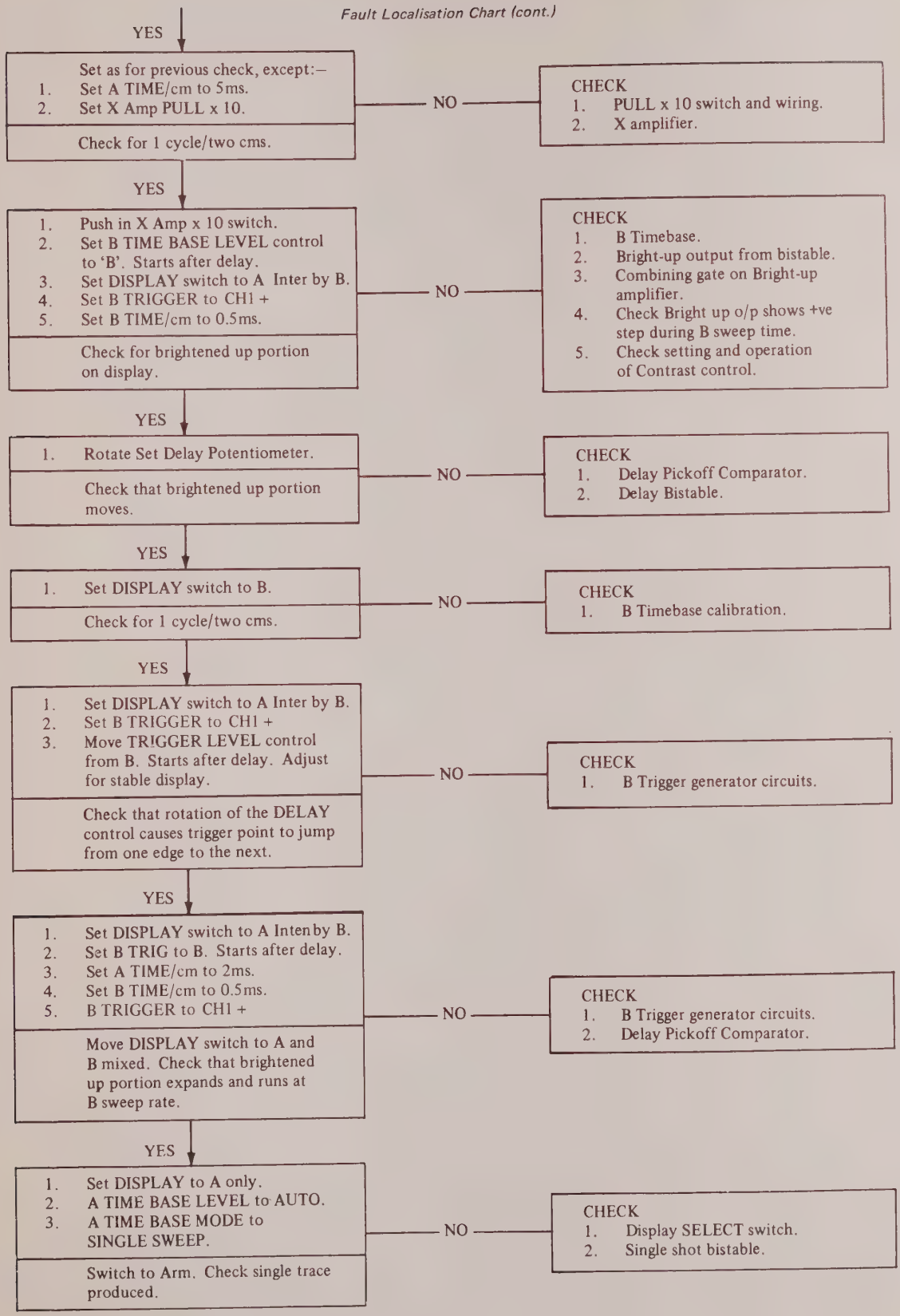
These are drawn for the following conditions. The 'A' timebase is switched to 0.1ms/cm and the 'B' timebase to 10μs/cm. A 5cm 10kHz square wave is applied to the CH1 channel, and the 'A' trigger set to CH1 +ve slope. The 'B' trigger is set to "B starts after delay", or to CH1 +ve slope. The delay multiplier potentiometer is set to about 5.


1. Set SUPPLY VOLTAGE selector to suit supply voltage.
2. Connect supply voltage and switch on.
Does front panel neon lamp light?
NO
CHECK
1. Supply voltage.
2. Rear panel fuse.
3. Front panel switch.
4. VOLTAGE SELECTOR switch
5. Power transformer.
6. Front panel neon.
YES
Check power supplies for tolerances given in Sect. 5-5.
Outside limits
1. Measure supply line voltage.
2. Check VOLTAGE SELECTOR setting.
3. Check and/or adjust affected supply.
YES
1. Set X and Y shift controls to mid range.
2. Set A TIME/cm to EXT.X
3. Ensure A Time Base PULL x 10 switch is pushed in.
Advance INTEN control and move MODE switch from CH1 to CH2. Can one or two spots be centred by shift controls.
NO
No spots
CHECK
1. Y amplifier (55V mean plate potential, etc.)
2. X amplifier (65V mean plate potential, etc.)
3. Bright-up amplifier (approx. 50V at collector (can) of TR971).
4. CRT circuit.
5. Beam switch circuit (approx. +7V and +2V at bistable collector.
1 spot or not centring
CHECK
1. Appropriate Y pre-amp circuit.
2. X and Y shift control circuits.
3. X amplifier.
4. Beam switch circuit.
YES
1. Set TIME BASE SELECT to 'A'.
2. TRIG SELECT to FREE RUN.
3. A TIME/cm to 1ms.
4. MODE to CH1 or CH2.
Does adjustment of INTEN, FOCUS and ASTIG produce two sharp traces.
NO
No trace
CHECK
1. A timebase.
2. Bright-up amplifier.
One trace or not sharp
CHECK
1. Beam switch circuit.
2. CRT circuit.
YES
1. Set TIME BASE SELECT to 'A'.
2. TRIG SELECT to FREE RUN.
3. A TIME/cm to 1ms.
4. MODE to ALT or CHOP.
Check for two trace operation in either mode.
NO
CHECK
1. Beam switch circuit.
2. Alt. trigger pulse from Timebase (should be approx. −1.5V).
YES
1. Set VOLT/cm switches to 0.2V.
2. Set VOLT/cm VARIABLE to CAL.
3. A TIME/cm to 0.5ms.
4. Set TIME/cm VARIABLE to CAL.
5. Set TRIG SEL to +ve and DC.
6. Set TRIG LEVEL to AUTO.
Inject 1V CAL waveform into either CH1 or CH2. Does it produce 1 cycle per two cms and 5 cms amplitude on both channels.
NO
Sweep speed error (For accurate check use Time Mark Generator)
CHECK
1. Timebase.
2. X amplifier.
3. Check calibrator.
Not 5cm.
CHECK
1. Appropriate Y Channel circuit.
2. Remaining Y amplifier circuits.
3. Check calibrator.
Not triggering
CHECK
1. Appropriate Y trigger amplifier.
2. Trigger course switch.
3. Timebase trigger amp.
4. Remaining A Timebase circuit.
YES

Fault Localisation Chart

continued overleaf

Fault Localisation Chart (cont.)


YES
Set as for previous check, except:–
1. Set A TIME/cm to 5ms.
2. Set X Amp PULL x 10.
Check for 1 cycle/two cms.
NO
CHECK
1. PULL x 10 switch and wiring.
2. X amplifier.
YES
1. Push in X Amp x 10 switch.
2. Set B TIME BASE LEVEL control to 'B'. Starts after delay.
3. Set DISPLAY switch to A Inter by B.
4. Set B TRIGGER to CH1 +
5. Set B TIME/cm to 0.5ms.
Check for brightened up portion on display.
NO
CHECK
1. B Timebase.
2. Bright-up output from bistable.
3. Combining gate on Bright-up amplifier.
4. Check Bright up o/p shows +ve step during B sweep time.
5. Check setting and operation of Contrast control.
YES
1. Rotate Set Delay Potentiometer.
Check that brightened up portion moves.
NO
CHECK
1. Delay Pickoff Comparator.
2. Delay Bistable.
YES
1. Set DISPLAY switch to B.
Check for 1 cycle/two cms.
NO
CHECK
1. B Timebase calibration.
YES
1. Set DISPLAY switch to A Inter by B.
2. Set B TRIGGER to CH1 +
3. Move TRIGGER LEVEL control from B. Starts after delay. Adjust for stable display.
Check that rotation of the DELAY control causes trigger point to jump from one edge to the next.
NO
CHECK
1. B Trigger generator circuits.
YES
1. Set DISPLAY switch to A Intenby B.
2. Set B TRIG to B. Starts after delay.
3. Set A TIME/cm to 2ms.
4. Set B TIME/cm to 0.5ms.
5. B TRIGGER to CH1 +
Move DISPLAY switch to A and B mixed. Check that brightened up portion expands and runs at B sweep rate.
NO
CHECK
1. B Trigger generator circuits.
2. Delay Pickoff Comparator.
YES
1. Set DISPLAY to A only.
2. A TIME BASE LEVEL to AUTO.
3. A TIME BASE MODE to SINGLE SWEEP.
Switch to Arm. Check single trace produced.
NO
CHECK
1. Display SELECT switch.
2. Single shot bistable.

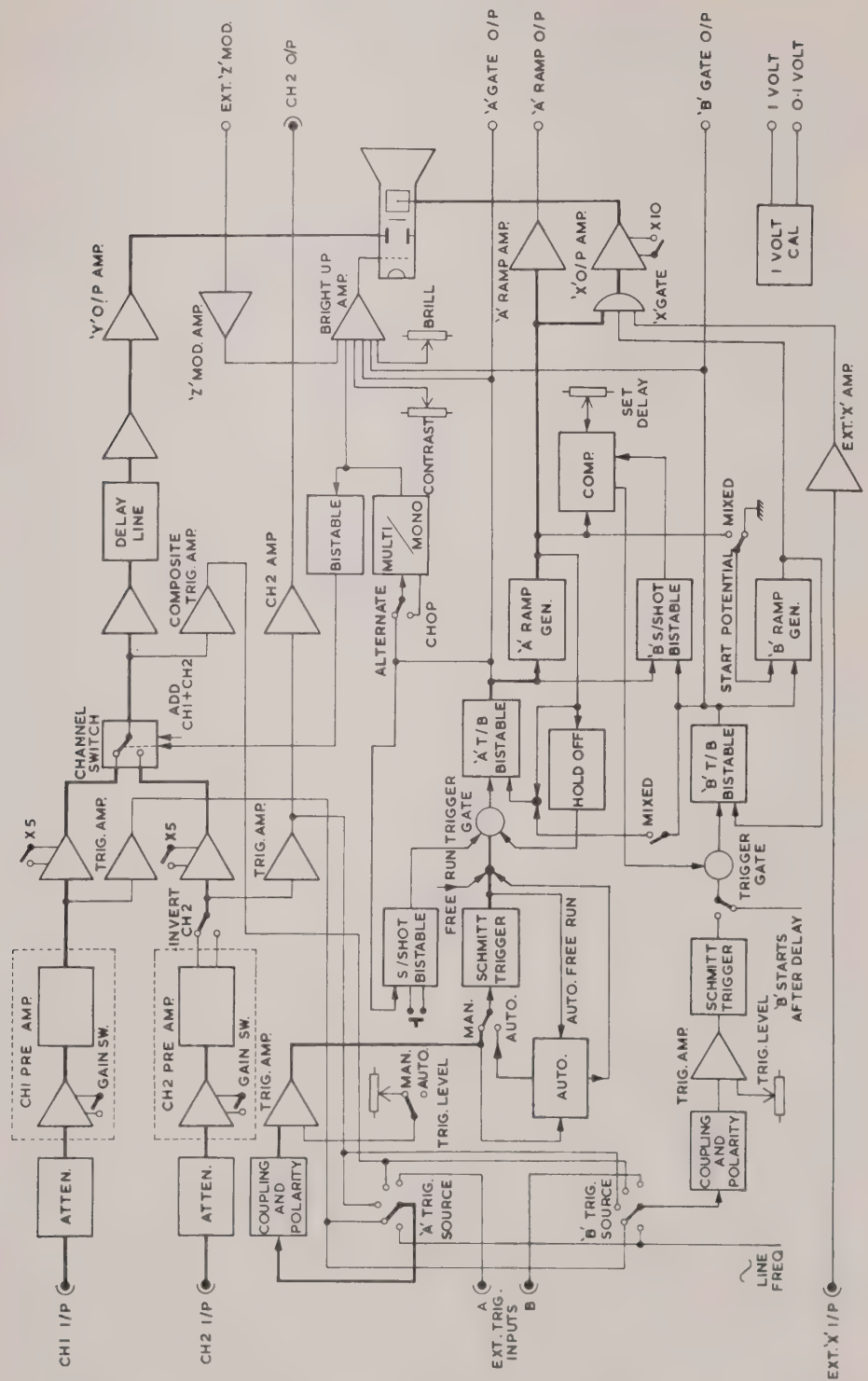


Fig. 1 Block Diagram.

ABBREVIATIONS USED FOR COMPONENT DESCRIPTIONS

RESISTORS

CC	Carbon Composition	½W	10%	unless otherwise stated
CF	Carbon Film	⅛W	5%	unless otherwise stated
MO	Metal Oxide	½W	2%	unless otherwise stated
MF	Metal Film	¼W	1%	unless otherwise stated
WW	Wire Wound	6W	5%	unless otherwise stated
CP	Control Potentiometer		20%	unless otherwise stated
PCP	Preset Potentiometer Type MPD, PC		20%	unless otherwise stated

CAPACITORS

CE(1)	Ceramic		+ 80% − 25%	
CE(2)	Ceramic	500V	± 10%	unless otherwise stated
SM	Silver Mica			
PF	Plastic Film		± 10%	unless otherwise stated
PS	Polystyrene			
PE	Polyester		± 10%	unless otherwise stated
PC	Polycarbonate			
E	Electrolytic (aluminium)		+ 50% − 10%	
T	Tantalum		+ 50% − 10%	

PRE-AMP 1 & 2 AND GAIN SWITCHING

Ref	Value	Description	Tol%±	Part No
RESISTORS				
R10	470	CP.	With S13	34779
R11	500	CP.		A4/31250
R101	270	CF.		28720
R102	270	CF.		28720
R103	3k3	CF.		21803
R104	3k3	CF.		21803
R105	1k2	CF.		21800
R106	1k2	CF.		21800
R107	1k	CF.		21799
R108	4k7	CF.		21805
R109	4k7	CF.		21805
R110	47	CF.		28714
R111	47	CF.		28714
R112	680	CF.		28723
R113	3k3	CF.		21803
R114	3k3	CF.		21803
R115	100	CF.		21794
R116	10	CF.		21793
R117	10	CF.		21793
R118	56	CF		28715
R119	10	CF		21793
R120	3k9	CF		21804
R121	680	CF		28723
R122	1k	CF		21799
R123	100	CP		33700
R124	1k	CF		21799
R125	110	MO	2	28783
R126		Not used		
R127	330	MO	2	26741
R128	330	MO	2	26741
R129	560	CF		21798
R130	10	CF		21793
R131	10	CF		21793
R132	390	MO	2	26740
R133	1k5	CF		21801
R134	390	MO		26740
R135	180	CF		21795
R136	100	PCP		28520
R137	680	CF		28723
R138	220	PCP		28522
R139	100	MO	2	26747
R140	100	MO	2	26747
R141	10	CF		21793
R142	10	CF		21793
R143	100	CF		21794
R144	100	CF		21794
R145	2k2	CF		21802
R146	1k	PCP		26870
R147	2k2	CF		21802
R148	100	CF		21794
R149	100	CF		21794
R150	270	CF		28720
R151	270	CF		28720
R153	10	CF		21793
R154	390	MO		26740
R155	390	MO		26740
R156	10	CF		21793
R157	10	CF		21793
R158	820	CF		28724
R159				
R160	27	CF		28711
R161				
R163	990k	MF		31927
R165	18	CF		28709
R167	10	CF		21793
R168	18	CF		28709
R169	10k1	MF		31928
R173	22	CF		28710
R175	10	CF		21793
R176	900k	MF		31929
R177	111k	MF		31930
R183	10	CF		21793
R184	10	CF		21793
R187	1M	MF		26346
R189	330k	CC	10	4408
R190	1k	CF		21799
CAPACITORS				
C101	.01μf	CE(2)		22395
C102	.01μf	CE(2)		22395
C103	.01μf	CE(2)		22395
C104	.01μf	CE(2)		22395
C120	4.7pF			4502
C121	1.5pF	CE(2)		813
C122	3/13pF	Trimmer		32059
C123	.7/6pF	Trimmer		29421
C124	220pF	CE(2)		22379
C125	220pF	CE(2)		22379
C126	.01μF	CE(2)		22395
C127	.01μF	CE(2)		22395
C128	.01μF	CE(2)		22395
C129	.01μF	CE(2)		22395
C130	1.5pF	CE(2)		813
C131	.01μF	CE(2)		22395
C132	.01μF	CE(2)		22395
C133	.01μF	CE(2)		22395
C155	.1μF	CE(2)		29495
C156	47pF	CE(2)		22372
C157	10pF	CE(2)		4504
C159	.7/6pF	Trimmer		25750
C161	.7/6pF	Trimmer		25750
C163	330pF	CE(2)		31293
C165	.7/6pF	Trimmer		25750
C167	.7/6pF	Trimmer		25750
C168	47pF	CE(2)		29918
C171	.7/6pF	Trimmer		25750
C173	5600pF	CE(2)		22394

Component List and Illustrations

Section 6

PRE-AMP 1 & 2 AND GAIN SWITCHING

Ref	Value	Description	Tol%±	Part No
DIODES				
D101		IN3595		29330
D102		1N3595		29330
D103	6V2	Zener		33930
D104	6V2	Zener		33930
D120	7V5	Zener		22173
D121	5V6	Zener		33929
D122	5V1	Zener		20218
D123				35202
TRANSISTORS				
TR101	AE12	Matched Pair		A31253
TR102				
TR103	AE13	Matched Pair		A31254
TR104				

Ref	Value	Description	Tol±	Part No.
TR120		2N2369		23307
TR121	AE13	Matched Pair		A31254
TR122				
TR123		2N2369		23307
TR124		2N2369		23307
TR125		2N2369		23307
TR126		2N2369		23307
MISCELLANEOUS				
S10				A2/31292
S11				35470
S13				34799
SKY				1222
L101				26986

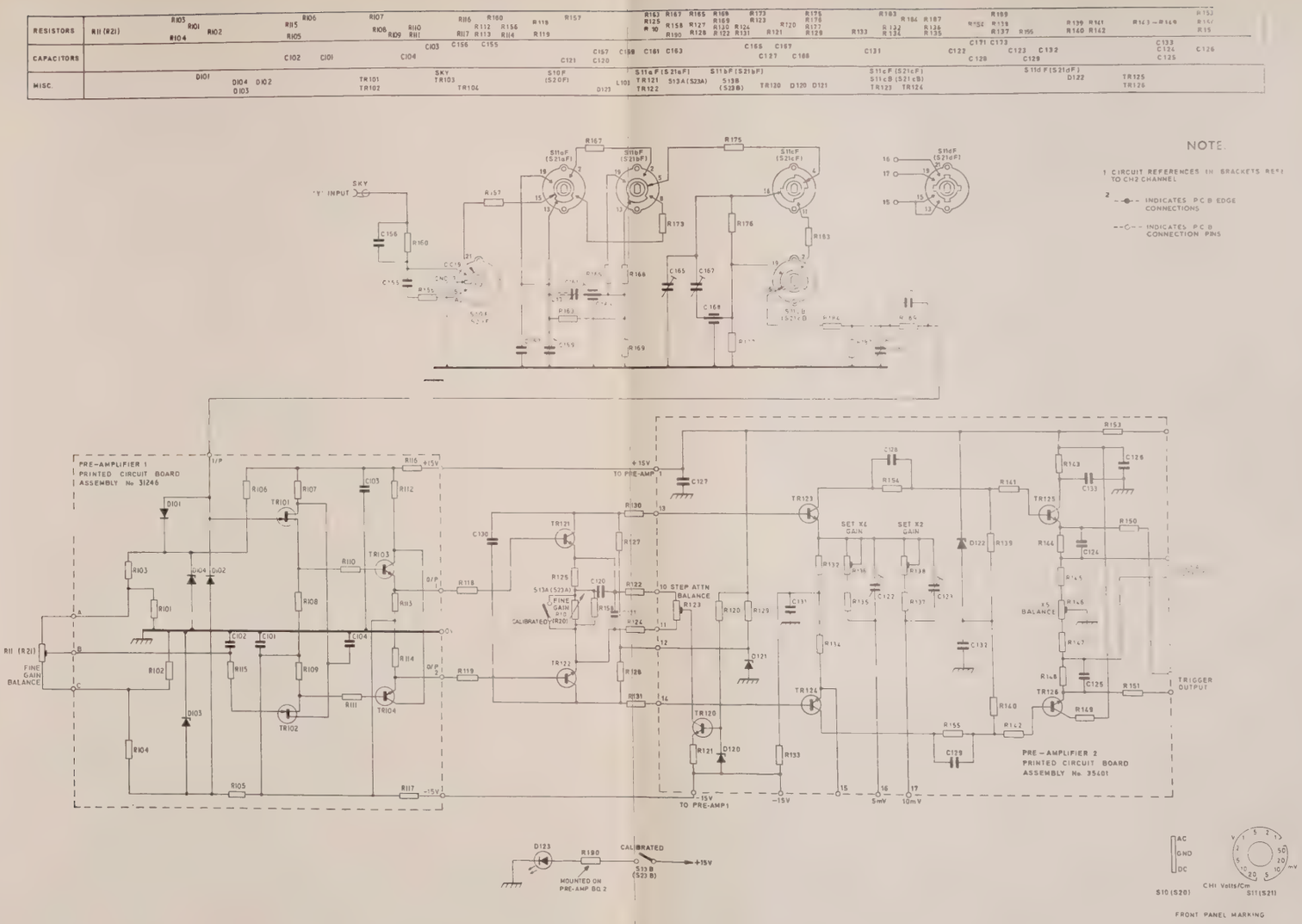


FIG.2. CIRCUIT DIAGRAM, PRE-AMP 1 AND 2 GAIN SWITCHING (AO/SK2402)

DELAY LINE DRIVER AND BEAM SWITCH

Ref	Value	Description	Tol%±	Part No
RESISTORS				
R200	10	CF		21793
R201	10	CF		21793
R202	10	CF		21793
R203	270	MO		26742
R204	10	CF		21793
R205	10	CF		21793
R206	270	MO		26742
R207	10	CF		21793
R208	10	CF		21793
R209	10	CF		21793
R210	10	CF		21793
R211	10	CF		21793
R212	56	CF		28715
R213	100	PCP		28520
R214	220	MO		26743
R215	1k5	CF		21801
R216	330	MO		26741
R217	180	CF		21795
R218	330	MO		26741
R219	330	MO		26741
R220	180	CF		21795
R221	330	MO		26741
R222	56	CF		28715
R223	100	PCP		28520
R224	220	MO		26743
R225	1k5	CF		21801
R226	680	CF		28723
R227	2k2	PCP		24561
R228	68	CF		28716
R229	100	PCP		28520
R230	27	CF	AOT	28711
R231	2k2	PCP		24561
R232	680	CF		28723
R233	100	PCP		28520
R234	68	CF		28716
R235	33	CF	AOT	28712
R236	68	CF		28716
R237	470	CF		21797
R238	470	PCP		28524
R239	39k	CF		28728
R240	1k8	CF		28725
R241	56	CF		28715
R242	2k2	CF		21802
R243	15k	CF		28727
R244	220	CF		21796
R245	3k9	MO		26724
R246	3k9	MO		26724
R247	470	MO		26739
R248	470	MO		26739
R249	330	MO		26741
R250	330	MO		26741
R251	220	CF		21796
R252	820	MO		26736
R253	820	MO		26736
R254	22	CF		28710
R255	1k8	CF		28725
R256	22	CF		28710
R257	1k2	MO		26734
R258	10	CF		21793
R259	10	CF		21793
R260	47	CF		28714
R261	120	CF		28718
R262	390	MO		26735
R263	39	CF		28713
R264	39	CF		28713
R265	180	CF	AOT	21795
R266	56	CF		28715
R267	150	CF		28719
R268	1k	CF		21799
R269	4k7	CF		21805
R270	820	CF		28724
R271	6k8	CF		21807
R272	6k8	CF		21807
R273	820	CF		28724
R274	10	CF		21793
R275	10	CF		21793
R276	4k7	CF		21805
R277	1k	CF		21799
R278	150	CF		28719
R279	390	CF		28722
R280	10k	CF		21809
R281	2k2	CF		21802
R282	3k3	CF		21803
R283	3k9	CF		21804
R284	1k8	CF		28725
R285	2k4	MO		26729
R286	470	CF		21797
R287	2k7	CF		28727
R288	10	CF		21793
R289	10	CF		21793
R290	10	CF		21793
R291	47	CF		28714
R292	47	CF		28714
R293	390	CF		26740
R294		A.O.T.		
R295		A.O.T.		
R296	100	CF.		21794
R297	100	PCP		28520
R298	56	CF		28715
R299	1k5	CF		21801
R323	100	CF		21794
CAPACITORS				
C200	100pF	CE(2)		22376
C201	.01μF	CE(2)		22395
C202	3/13pF	Trimmer		18803
C203	.1μF	CE(1)	30V	19647
C204	100pF	CE(2)		22376
C205	.1μF	CE(1)	30V	19647
C206	3/13pF	Trimmer		18803

DELAY LINE DRIVER AND BEAM SWITCH (Cont.)

Ref	Value	Description	Tol%±	Part No
C209	15pF	CE(2)		22366
C210	15pF	CE(2)		22366
C211	10/40pF	Trimmer		29483
C212	330pF	CE(2)		22381
C213	33pF	CE(2)		22370
C214	.01μF	CE(2)		22395
C215	15pF	CE(2)		22366
C216	15pF	CE(2)		22366
C217	.01μF	CE(2)		22395
C218	33pF	CE(2)		22370
C219	330pF	CE(2)		22381
C220	.01μF	CE(2)		22395
C221	900pF	PE	1 125V	24885
C222	.01μF	CE(2)		22395
C223	47pF	CE(2)		22372
C224	.01μF	CE(2)		22395
C225	.1μF	CE(1)	30V	19647
C226	22μF	E	25V	32181
C227	3300pF	CE(2)		22391
C228	27pF	CE(2)	A.O.T.	22369
C229	3300pF	CE(2)		22391
C230	330pF	CE(2)		22381
C231	330pF	CE(2)		22381
C232	100μF	E	25V	32183

TRANSISTORS

TR201	AE 16		A31781
TR202	AE 16		A31781
TR203	AE 16		A31781
TR204	AE 16		A31781
TR205	AE 17	Matched Pair	A32063
TR206			
TR207	AE 16		A31781
TR208	AE 16		A31781
TR209	2N2369	I.T.T. only	33701
TR210	2N2369	I.T.T. only	33701
TR211	2N2369	I.T.T. only	33701
TR212	AE 16		A31781
TR213	AE 16		A31781
TR214	AE 16		A31781
TR215	2N2369	I.T.T. only	33701
TR216	2N2369	I.T.T. only	33701
TR217	2N2369	I.T.T. only	33701
TR218	2N2369	I.T.T. only	33701
TR219	AE 16		A31781
TR220	AE 16		A31781

DIODES

D201	IN916		1949
D202	IN916		1949
D203	IN916		1949
D204	IN916		1949
D205	IN916		1949
D206	IN916		1949
D207	IN916		1949
D208	IN916		1949
D209	5V6	Zener	33929
D211		IN4148	23802
D212		IN4148	23802
D213		OA 47	4468
D214		OA 47	4468

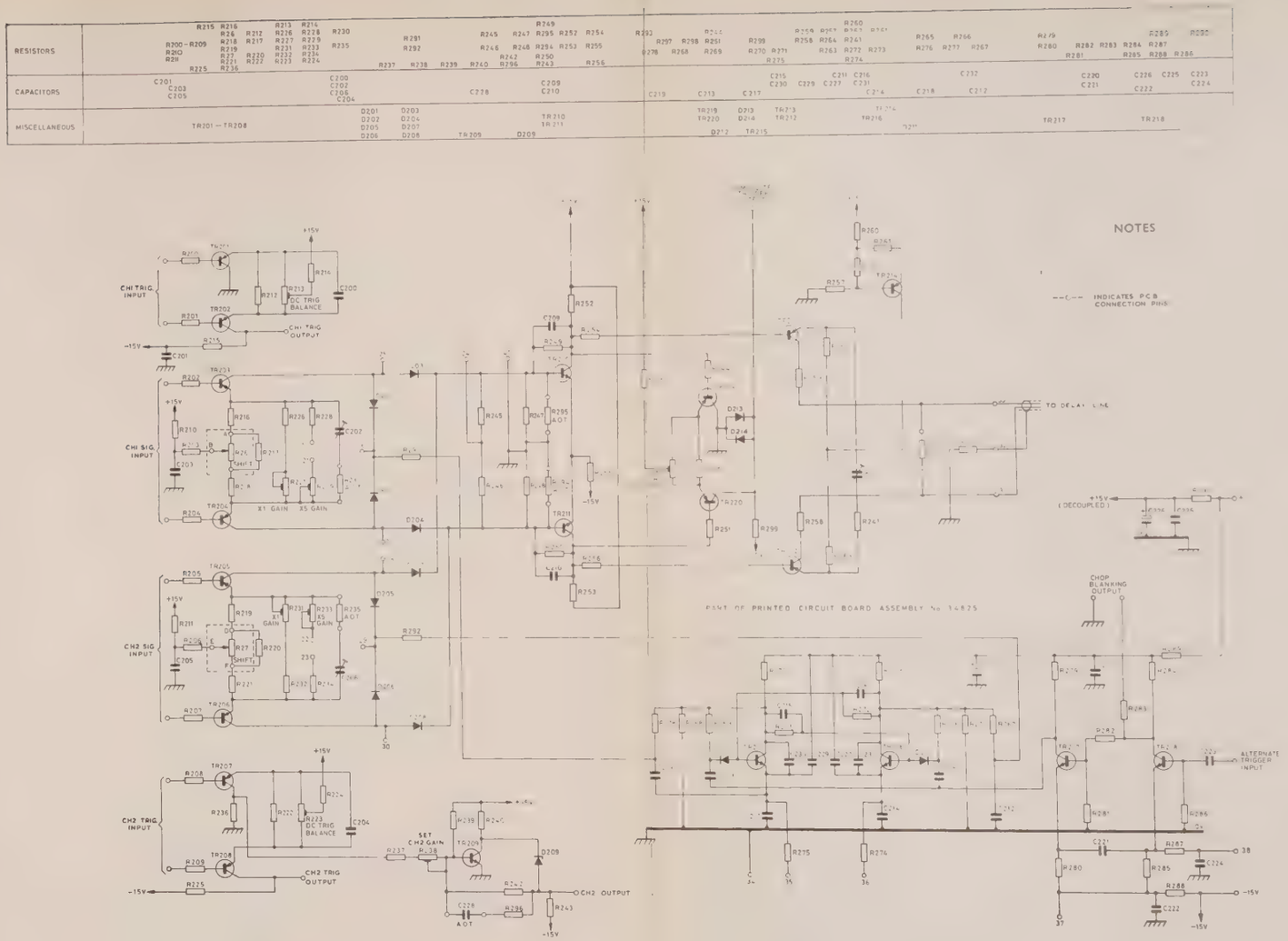
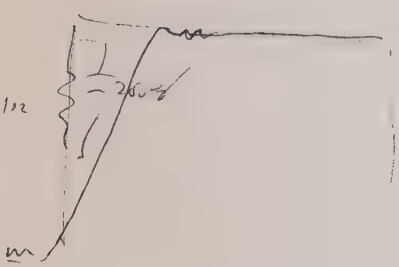


FIG.3. CIRCUIT DIAGRAM, DELAY LINE DRIVER AND BEAM SWITCH (AO/SK2401)



DELAY EQUALISER & OUTPUT DRIVER

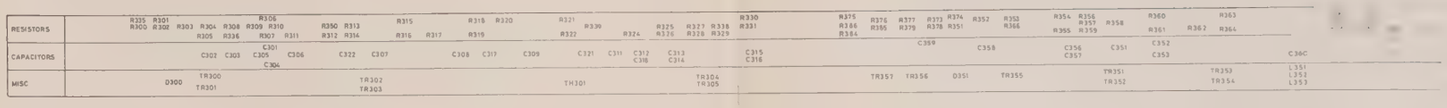
Ref	Value	Description	Tol%±	Part No
RESISTORS				
R300	1k8	CF AOT		28725
R301	100	MO		26747
R302	100	MO		26747
R303	3k3	CF		21803
R304	22	CF		28710
R305	22	CF		28710
R306	390	MO		26740
R307	390	MO		26740
R308	8k2	CF		21808
R309	22k	PCP		25885
R310	22k	CF		21812
R311	10k	PCP		28525
R312	390	MO		26740
R313	39	CF		28713
R314	39	CF		28713
R315	100	CF		21794
R316	100	CF		21794
R317	560	MO		26737
R318	100	MO		26747
R319	100	MO		26747
R320	47	CF		28714
R321	22	CF		28710
R322	22	CF		28710
R323	Used on Delay Line Driver			
R324	2k2	PCP		24561
R325	3k3	CF		21803
R326	3k3	CF		21803
R327	56	MO		28777
R328	56	MO		28777
R329	560	MO		26737
R330	150	MO		26745
R331	150	MO		26745
R332				
R333				
R334				
R335	10	CF		21793
R336	10	CF		21793
R337				
R338	100k	CF		21819
R339	47	CF		28714
R350	10	CF		21793
R351	2k2	CF		21802
R352	47	CF		28714
R353	39	CF		28713
R354	56	MO		28777
R355	56	MO		28777
R356	10	CF		21793
R357	100	PCP		28520
R358	22k	MO		21812
R359	10	MO		21793
R360	56	MO		28777
R361	56	MO		28777
R362	56	CF		28715
R363	56	CF		28715
R364	56	CF		28715
R365	390	CF		19038
R366	180	CF		21795
R367				
R368	390	CF	1W	19038
R369				
R370	390	CF	1W	19038
R371	390	CF	1W	19038
R372				
R373	270	CF		28720
R374	10	CF		21793
R375	100	CF		21794
R376	1k8	CF		28725
R377	10	CF		21793
R378	270	CF		28720
R379	680	CF		28723
R380				
R381	220k	PCP		29363
R382	120k	CF		21820
R383	560	WW	6W	19218
R384	100	CF		21794
R385	10	CF		21793
R386	150	CF		28719
R387	2k2	CF		21802
CAPACITORS				
C301	1000pF	CE(2)		22387
C302	.22μF	PE	160V	31379
C303	47pF	CE(2)		22372
C304	1000pF	CE(2)		22387
C305	680pF	CE(2)		22385
C306	39pF	CE(2)		22371
C307	.01μF	CE(2)		22395
C308	.01μF	CE(2)		22395
C309	.01μF	CE(2)		22395
C310				
C311	10/40pF	Trimmer		29483
C312	27pF	CE(2)		22369
C313	33μF	E	16V	32173
C314	33μF	E	16V	32173
C315	1000pF	CE(2)		22387
C316	1000pF	CE(2)		22387
C317	.01μF	CE(2)		22395
C318	.01μF	CE(2)		22395
C321	4.7pF	CE(2)		4502
C322	3/13pF	Trimmer		18803
C323	4.7pF	CE(2)		4502
C351	680pF	CE(2)		22385
C352	100pF	CE(2)		22376
C353	100pF	CE(2)		22376
C354	.01μF	CE(2)		22395
C355	.01μF	CE(2)		22395
C356	.01μF	CE(2)		22395
C357	25pF	Trimmer		23593
C358	.01μF	CE(2)		22395
C359	.01μF	CE(2)		22395
C360	.01μF	CE(2)		22395

TRANSISTORS

TR300	AE 16		A31781
TR301	AE 16		A31781
TR302	2N2369	I.T.T. only	33701
TR303	2N2369	I.T.T. only	33701
TR304	2N2369	I.T.T. only	33701
TR305	2N2369	I.T.T. only	33701
TR351	2N2369	I.T.T. only	33701
TR352	2N2369	I.T.T. only	33701
TR353	2N3119		31255
TR354	2N3119		31255
TR355	2N2369	I.T.T. only	33701
TR356	2N2369	I.T.T. only	33701
TR357	2N2369	I.T.T. only	33701

DIODES

D300	3V9	Zener	33925
D351	3V3	Zener	33923
L351	3.3μH		31256
L352	3.3μH		31256
L353			26986



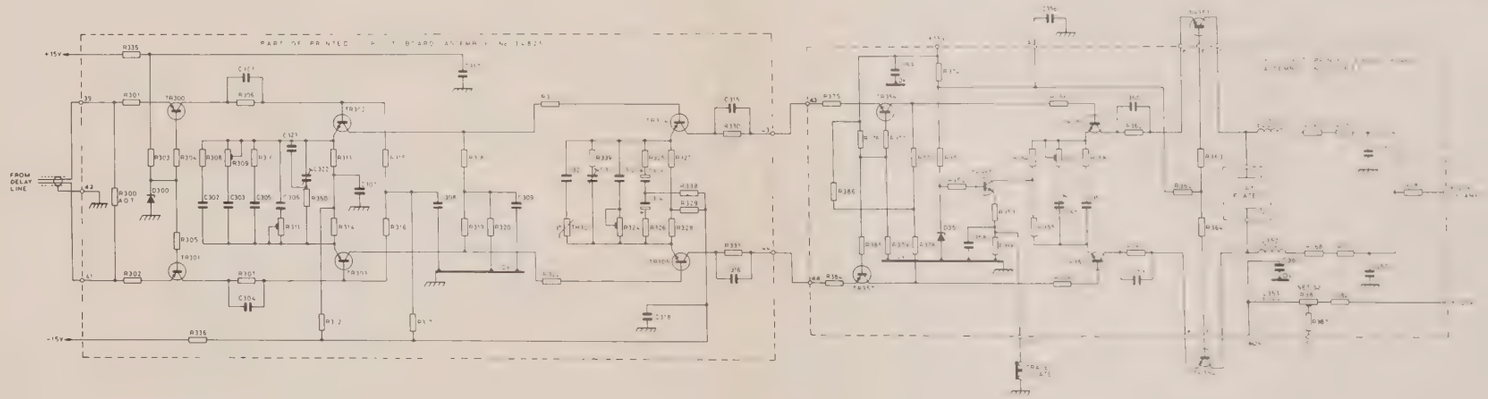


FIG.4. CIRCUIT DIAGRAM, DELAY EQUALISER AND OUTPUT DRIVER (AO/SK2400)

'A' TIMEBASE

RESISTORS

Ref	Value	Description	Tol%±	Part No.
R400	47	CF		28714
R401	100k	CF	1W	19061
R402	2k2	CF		21802
R403	10	CF		21793
R404	47	CF		28714
R405	47	CF		28714
R406	47	CF		28714
R407	4k7	CF		21805
R408	1k5	CF		21801
R409	10k	CF		21809
R410	1k	CF		21799
R411	3k9	CF		21804
R412	100	CF		21794
R413	2k7	CF		28726
R414	220	CF		21796
R415	1k5	CF	½W	18552
R416	560	CF		21798
R417	8k2	CF		21808
R418	470k	CF		32330
R419				
R420	10k	CF		21809
R421	220k	CF		21823
R422	33k	CF		21814
R423	22k	CF		21812
R424	1k8	CF		28725
R425	33k	CF		21814
R426	1k	CF		21799
R427	1k	CF		21799
R428	100k	CF		21819
R429	470	CF		21797
R430	560k	CF		32359
R431	100	CF		21794
R432	4k7	CF		21805
R433	150k	CF		21821
R434	3k9	CF		21804
R435	39	CF		28713
R436	47	CF		28714
R437	12k	CF		21810
R438	100	CF		21794
R439	10	CF		21793
R440		Part of Switch Trigger		34818
R441	4k7	CF		21805
R442	22	CF		28710
R443	3k3	CF		21803
R444	4k7	CF		21805
R445	1k5	CF		21801
R446				
R447	100k	CF		21819
R448	27k	CF		21813
R449				
R450	4k7	CF		21805
R451	47	CF		28714
R452	680	CF		28723
R453	1k	CP		26870
R454	1k3	MO		28792
R455	3k3	CF		21803
R456	1k5	CF		21801
R457	100	CF		21794
R458	5k6	CF		21806
R459	10	CF		21793
R460	10	CF		21793
R461	330	CF		28721
R462	33k	CF		21814
R463	10	CF		21793
R464	10	CF		21793
R465	820	CF		28724
R466	22k	CF		21812
R467	470	CF		21797
R468	220k	CF		21823
R469	470	CF		21797
R470	390	CF		28722
R471	4k7	CF		21805
R472	2k7	CF		28726
R473	10	CF		21793
R474	220	CF		21796
R475	1k	CF		21799
R476	1k5	CF		18552
R477	91	MO		28782
R478	1k2	CF		21800
R479	8k2	CF		21808
R480				
R481	180k	CF		21822
R482	1k2	CF		21800
R483	22k	CF		21812
R484	4k7	CF		21805
R485	620	CF		22485
R486	22k	CF		21812
R487	1k8	CF		28725
R488	10	CF		21793
R489	750	CC		1179
R490	10	CF		21793
R491	470	CF		21797
R492	4k7	CF		21805
R493	820	CF		28724
R494	100k	CF		21819
R495	1k5	CF		21801
R496	10	CF		21793
R497	10	CF		21793
R498	120k	CF		21820
R499	8k2	CF		21808
R500	6k8	CF		21807
R501	820	CF		28724
R502	100k	CF		21819
R503	8k2	CF		21808
R504	3k3	CF		21803
R505	1k2	CF		21800
R506	4k7	CF		21805
R507				
R508	4k7	CF		21805
R509	1k2	CF		21800
R510	470	CP		28524
R511	10k	CF		21809
R512	3k3	MO		26726
R513	100	CF		21794

'A' TIMEBASE (Cont.)

Ref	Value	Description	Tol%±	Part No
RESISTORS				
R514	3k3	MO		26726
R515	100	CF		21794
R516	10k	CF		21809
R517	10k	CF		21809
R518	8k2	CF		21808
R519	10k	CF		21809
R520	10k	CF		21809
R521	10k	CF		21809
R522	10k	CF		21809
R523	100	CF		21794
R524	47k	CF		21815
R525	6k8	CF		21807
R526	470	CF		21797
R527	100	CF		21794
R528	15k	CF		28727
R529	1k5	CF		21801
R530	10k	CF		21809
R531	47k	CF		18570
R532	390	CF		18545
R533	6k8	CF		21807
R534	1k	CF		21799
R535	4k7	CF		21805
R536	1k	CF		21799
R537	10	CF		21793
R538	10M	CC		1179
R539	47	CF		28714
R540	4k7	CF		21805
R541	10k	CF		21809
R542	6k8	CF		21807
R543	4k7	CF		21805
R544	1k3	CC		33338
R545	100	CF		21794
R546	47	CF		28714
R547	47	CF		28714
R548	100k	CF		21819
R549	2k7	CF		28726
R550	10	CF		21793
R551	390	CF		28722
R552	100k	CF		21819
R553	2k	MO		26731
R554	680	CF		28723
R555	1k	CF		21799
R556	1k8	CF		28725
R557	33	CF		28712
R558	47	CF		28714
R559	100	CF		21794
R560	47k	CF		21815
R561 to R570 Shown on Interconnection				
R571	22	CF		28710
R572	470	CF		21797
R573		Not used		
R574	3k9	CF		21804
R575				
R576	100	CF		21794
R577	47	CF		28714
R578	15	CF		28708
R579	15	CF		28708
CAPACITORS				
C400	4.7pF	SM		4502
C401	220pF	CE(2)		22379
C402	.47μF	PE	160V	31381
C403	470pF	CE(2)		22383
C404	33pF	CE(2)		22370
C405	100pF	CE(2)		22376
C406	10pF	CE(2)		22364
C407	33pF	CE(2)		22370
C408	47pF	CE(2)		22372
C409	.01μF	CE(2)		22395
C410	1000pF	CE(2)		22387
C411	.1μF	PE	160V	31377
C412	.1μF	PE	160V	31377
C413	100pF	CE(2)		22376
C414	1000pF	CE(2)		22387
C415	220pF	CE(2)		22379
C416	Not used			
C417	.1μF	CE(1)	160V	19647
C418	.1μF	CE(2)	160V	31377
C419	.01μF	CE(2)		22395
C420	22pF	CE(2)		22368
C421	.1μF	CE(1)		19647
C422	.1μF	CE(1)		19647
C423	1000pF	CE(2)		22387
C424	390pF	CE(2)		22382
C425	22μF	E	25V	32181
C426	27pF	CE(2)		22369
C427	.01μF	CE(2)		22395
C428	.01μF	CE(2)		22395
C429	1.5pF	SM		813
C430	22pF	CE(2)		22368
C431	18pF	CE(2)		22367
C432	6.8pF	CE(2)		22362
C433	.01μF	CE(2)		22395
C434	.01μF	CE(2)		22395
C435	6/25pF	Trimmer		23593
C436	100pF	CE(2)		22376
C437	100pF	CE(2)		22376
C438	100pF	CE(2)		22376
C439	.01μF	CE(2)		22395
C440	33pF	CE(2)		22370
C441	.1μF	CE(1)		19647
C444	.01μF	CE(2)		22395
C446	.1μF	CE(2)		19647
C447	220pF	CE(2)		22379
C448	.01μF	CE(2)		22395
C449	.01μF	CE(2)		22395
C450	.01μF	CE(2)		22395
C451	.01μF	CE(2)		22395
C452	33μF	E		32175

'A' TIMEBASE (Cont.)

Ref	Value	Description	Tol%±	Part No.
C453	.01μF	CE(2)		22395
C454	1000pF	CE(2)		22387
C455	100pF	CE(2)		22376
C462	.01μF	CE(2)		22395
C463	4.7pF	CE(2)		29649
C465	27pF	CE(2)		22369
C466	1500pF	CE(2)		22388
C467	.01μF	CE(2)		22395

TRANSISTORS

TR401	BSX20		23307
TR402	BSX20		23307
TR403	BC107		26790
TR404	2N3906		21533
TR405	BC107		26790
TR406	2N3906		21533
TR407	BC108		26110
TR408	Not used		
TR409	2N930		21548
TR410	2N3906		21533
TR411	2N3906		21533
TR412	BC107		26790
TR413	AE13	Matched Pair	31254
TR414			
TR415	MPS 3640		24128
TR416	MPS 3640		24128
TR417	BSX20		23307
TR418	BC108		26110
TR419	BSX20		23307
TR420	2N2369		23307
TR421	2N3906		21533
TR422	2N3906		21533
TR423	2N930		21548
TR424	BC108		26110
TR425	AE12	Matched Pair	31253
TR426			
TR427	BC107		26790
TR428	2N3906		21533
TR429/436	AE13	Matched Pairs	31254
TR430	2N3906		21533
TR431	MPS3640		24128
TR432	2N3906		21533
TR433	C407		20388
TR434	MPS3640		24128
TR435	BSX20		23307
TR436	see TR429		
TR437	BSX20		23307
TR438	BSX20		23307

DIODES

D401	1N 4148		23802
D402	1N 4148		23802
D403	1N 4148		23802
D404	1N 4148		23802
D405	1N 4148		23802
D406	1N 4148		23802
D407	1N 4148		23802
D408	1N 4148		23802
D409	1N 4148		23802
D410	1N 4148		23802
D411	1N4148		23802
D412	1N4148		23802
D413	Not used		
D414	OA47		4468
D415	OA47		4468
D416	1N 4148		23802
D417	1N 4148		23802
D418	1N 4148		23802
D419	AAZ13		4472
D420	1N 4148		23802
D421	1N 4148		23802
D422	1N 4148		23802
D423	6V8	Zener	4666
D424	1N 4148		23802
D425	OA47		4468
D426	1N 4148		23802
D427	1N 4148		23802
D428	1N 4148		23802
D429	1N 3595		29330
D430	Not used		
D431	1N 4148		23802
D432	1N 4148		23802
D433	1N 4148		23802
D434	4V7	Zener	4073
D435	1N 4148		23802
D436	1N 4148		23802
D437	Not used		
D438	Not used		
D439	1N 4148		23802

MISCELLANEOUS

IC400	SN7400N		52038
L402	Bead Ferrite FX1242		26986
N400			26586
S40			34818
S41	Part of R440		A3/35756
S42			
S44			A3/31267
SKE	50Ω B.N.C.		1222

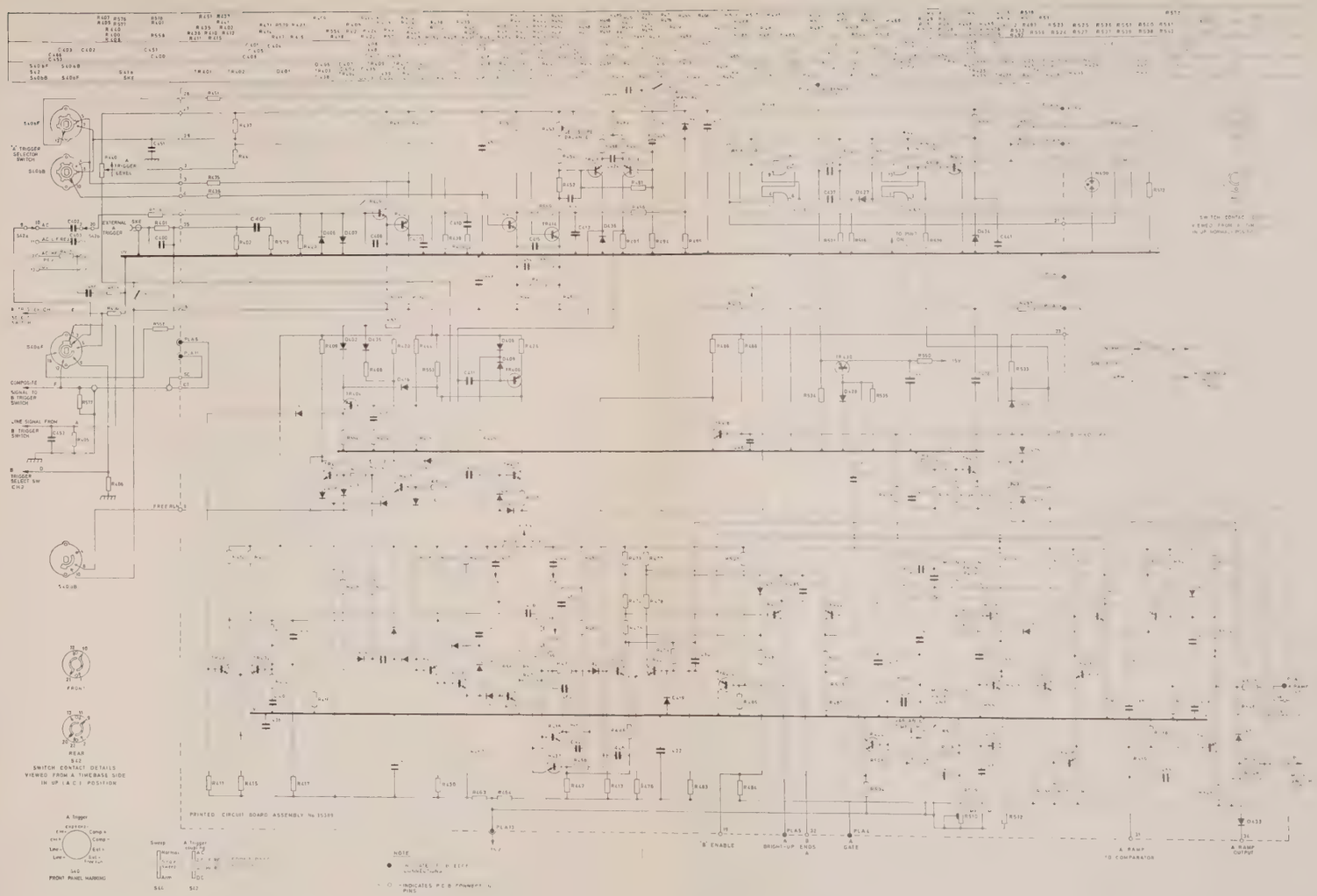


FIG.5. CIRCUIT DIAGRAM, A TIME BASE (AO/SK2404)

'B' TIMEBASE

Ref	Value	Description		Tol%±		Part No
RESISTORS						
R600	3k9	CF		5	1/8W	21804
R601	1k5	CF				21801
R602	1k+1k	CP				A4/35293
R603	1k+1k	CP				A4/35293
R604	1k8	CF				28725
R605	10k	CF				21809
R606	3k9	CF				21804
R607	1k	CF				21799
R608	1k5	CF			½W	18552
R609	390	CF				28722
R610	8k2	CF				21808
R611	100	CF				21794
R612	4k7	CF				21805
R613	470	CF				21797
R614	100k	CF				19061
R615	2k2	CF				21802
R616	15	CF				28708
R617	22k	CF				21812
R618	200k	MO				28829
R619	150k	MO		2		28826
R620	47k	MO		2		28814
R621	1M	MO				31840
R622	13k	MO		2		28803
R623	2k	MO		2		26731
R624	5k6	MO		2		22483
R625	2k9	CF				21802
R626	100	CF				21794
R627	150k	CF				21821
R628	4k7	CF				21805
R629	3k9	CF				21804
R630	39	CF				28713
R631						
R632	470	PCP				28524
R633	47	CF				28714
R634	12k	CF	A.O.T.			21810
R635	10	CF				21793
R636	100	CF				21794
R637	4k7	CF				21805
R638	4k7	CF				21805
R639	47	CF				28714
R640	3k3	CF				21803
R641	22	CF				28710
R642	3k3	CF				21803
R643	1k	PCP				26870
R644	1k3	MO		2		28792
R645	680	CF				28723
R646	1k5	CF				21801
R647	10	CF				21793
R648	10	CF				21793
R649	10	CF				21793
R650	10	CF				21793
R651	3k6	MO				26725
R652	820	CF				28724
R653	10	CF				21793
R654	10	CF				21793
R655	680	CF				28723
R656	470	CF				21797
R657	470	CF				21797
R658	10	CF				21793
R659	27k	CF				21813
R660	47	CF				28714
R661	1k5	CF				21801
R662	10	CF				21793
R663	6k8	CF				21807
R664	470	CF				21797
R665	6k8	CF				21807
R666	1k	CF				21799
R667	47	CF				28714
R668	1k5	CF				21801
R669	2k7	CF				28726
R670	4k7	CF				21805
R671	2k7	CF				28726
R672	15k	CF				28727
R673	10	CF				21793
R674	220	MO		2		26743
R675	1k	CF				21799
R676	330	CF				28721
R677	91	MO		2		28782
R678	1k2	CF				21800
R679	8k2	CF				21808
R680	2k2	CF				21802
R681	680	CF				28723
R682	820	CF				28724
R683	1k8	CF				28725
R684	8k2	CF				21808
R685	1k5	MO		2		26733
R686	2k2	MO		2		26730
R687	8k2	MO		2		28798
R688	22k	CF				21812
R689	47	CF				28714
R690	4k7	CF				21805
R691	2k7	CF				28726
R692	22k	CF				21812
R693	22k	CF				21812
R694	2k2	MO		2		26730
R695	1k	PCP				26870
R696	1k2	CF				21800
R697	4k7	CF				21805
R698	680	CF				28723
R699	2k7	CF				28726
R700	4k7	CF				21805
R701	680	CF				28723
R702	100	CF				21794
R703	4k7	CF				21805
R704	3k3	CF				21803
R705	100	CF				21794
R706	2k2	CF				21802
R707	1k8	CF				28725
R708	2k2	PCP (WMP.PC)				27188
R709	100	CF				21794
R710	6k8	CF				21807
R711	10M	CC		10	½	1179

'B' TIMEBASE

Ref	Value	Description	Tol%±	Part No
RESISTORS (Contd.)				
R712		Not used		
R713	13k	MO	2	28803
R714	100	CF		21794
R715	22k	CP		A4/35293
R716	820k	CF		32360
R717	3k3	CF		21803
R718	4k3	MO	2	26723
R719	3k9	CF		21804
R720	10k	CF		21809
R721	6k8	CF		21807
R722	47k	CF		21815
R723	100	CF		21794
R724	4k7	CF		21805
R725	1k	CF		21799
R726	220	CF		21796
R727	470	CF		21797
R728	10k	MO	2	28800
R729	10	CF		21793
R730	1k	PCP		26870
R731	13k	MO	2	28803
R732				
R733	47	CF		28714
R734	4k7	CF		21805
R735	1k	CF		21799
R736	680	CF		28723
R737	47	CF		28714
R738	3k9	CF		21804
R739	6k2	MO	2	28795
R740	470	CF		21797
R741	100k	CF		21819
R742	2k7	CF		28726
R743	5k6	CF		21806
R744	1k	CP 10 Turn		A4/31264
R745	4.7	CF		29433
R746	470	CF		21797
R747				
R748	3M	Welwyn 4034G MF.	1	35440
R749	1M	MF		26346
R750	499k	Welwyn MF 4034G	1%	26342
R751	300k	" " "		35439
R752	100k	" " "		29476
R753	49k9	" " "		29475
R754	30k	" " "		35438
R755	10k	" " 4033Z		27308
R756	10k	" " "		27308
R757	33	CF		28712
R758	3k9	CF		21804
R759	10k	CF		21809
R760		Not used		
R761	100	CF		21794
R762	4k7	CF		21805
R763	15	CF		28708
CAPACITORS				
C601	4.7pF	SM		4502
C602	220pF	CE(2)		22379
C603	10pF	CE(2)		22364
C604	33pF	CE(2)		22370
C605	100pF	CE(2)		22376
C606	8.2pF	CE(2)		22363
C607	10pF	CE(2)		22364
C608	.01μF	CE(2)		22395
C609	47pF	CE(2)		22372
C610	470pF	CE(2)		22383
C611	.47	CE(2)		31381
C612	.01μF	CE(2)		22395
C613	.1μF	CE(1)	30V	19647
C614	.1μF	CE(1)	30V	19647
C615	.1μF	CE(1)	30V	19647
C616	1000pF	CE(2)		22387
C617	1000pF	CE(2)		22387
C618	1000pF	CE(2)		22387
C619	390pF	CE(2)		22382
C620	22pF	CE(2)		22368
C621	.01μF	CE(2)		22395
C622		Not used		
C623	.01μF	CE(2)		22395
C624	.01μF	CE(2)		22395
C625	.01μF	CE(2)		22395
C626	22pF	CE(2)		22368
C627	33pF	CE(2)		22370
C628	18pF	CE(2)		22367
C629	18pF	CE(2)		22367
C630	33pF	CE(2)		22370
C631	6/25pF	Trimmer		23593
C632	4.7pF	CE(2)		29649
C633	.01μF	CE(2)		22395
C634	.33μF	PE		31380
C635	22μF	E	25V	32181
C636	.01μF	CE(2)		22395
C637	.01μF	CE(2)		22395
C638	.01μF	CE(2)		22395
C639	.01μF	CE(2)		22395
C640	33pF	CE(2)		22370
C641	330pF	CE(2)		22381
C642	330pF	CE(2)		22381
C643	.01μF	CE(2)		22395
C644	.1μF	CE(1)	30V	19647
C645	6/25pF	Trimmer		23593
C646	33μF	E		32173
C647	.1μF	CE(1)	30V	19647
C648	.01μF	CE(2)		22395
C655	1000pF	CE(2)		22387
C656	.01μF	CE(2)		22395
TRANSISTORS				
TR601		BSX 20 (2N2369)		23307
TR602		BSX 20 (2N2369)		23307
TR603		2N930		21548
TR604		2N3906		21533
TR605		2N930		21548
TR606		2N3906		21533
TR607				
TR608		AE13 Matched Pair		31254

'B' TIMEBASE

Ref	Value	Description	Tol%±	Part No	Ref	Value	Description	Tol%±	Part No
TRANSISTORS (Contd.)					D603		IN4148 (IN914)		23802
TR609		MPS3640		24128	D604		IN4148 (IN914)		23802
TR610		MPS3640		24128	D605		IN4148 (IN914)		23802
TR611		BSX20 (2N2369)		23307	D606		Zener 6.8V		4666
TR612		BSX20 (2N2369)		23307	D607		Zener 8.2V		3798
TR613		BSX20 (2N2369)		23307	D608		IN4148 (IN914)		23802
TR614		AE13 Matched Pair		31254	D609		IN4148 (IN914)		23802
TR615		2N3906		21533	D610		IN4148 (IN914)		23802
TR616		2N3906		21533	D611		IN4148 (IN914)		23802
TR617		See TR614			D612		IN4148 (IN914)		23802
TR618		2N3906		21533	D613		IN3595		29330
TR619		2N3906		21533	D614		IN4148 (IN914)		23802
TR620		BSX20 (2N2369)		23307	D615		IN4148 (IN914)		23802
TR621		BSX20 (2N2369)		23307	D616		IN4148 (IN914)		23802
TR622		AE15		32067	D617		IN4248 (IN914)		23802
TR623		BC108		26110	D618		IN4148 (IN914)		23802
TR624		BC108		26110	D619		IN4148 (IN914)		23802
TR625		BC108		26110	D620		IN4148 (IN914)		23802
TR626		2N3906		21533	D621		IN4148 (IN914)		23802
TR627		BC107		26790	D622		IN4148 (IN914)		23802
TR628		MPS3640		24128	D623		IN4148 (IN914)		23802
TR629		2N3906		21533	D624		IN4148 (IN914)		23802
TR630		BSX20 (2N2369)		23307	D625		IN4148 (IN914)		23802
TR631		BSX20 (2N2369)		23307	D626		IN4148 (IN914)		23802
TR632		BC108		26110	D627		IN4148 (IN914)		23802
TR633		BSX20 (2N2369)		23307	D628		IN4148 (IN914)		23802
L601		Bead Ferrite FX1242		26986	D629		IN4148 (IN914)		23802
L602	3.3μH	Choke		31256	D630		IN4148 (IN914)		23802
L603		Bead Ferrite FX1242		26986	D631		IN4148 (IN914)		23802
DIODES					D632		IN916		1949
D600		IN3595		29330	D633		IN916		1949
D601		IN4148 (IN914)		23802	D634		Interconnect. Circuit		
D602		IN4148 (IN914)		23802	D635		IN4148 (IN914)		23802

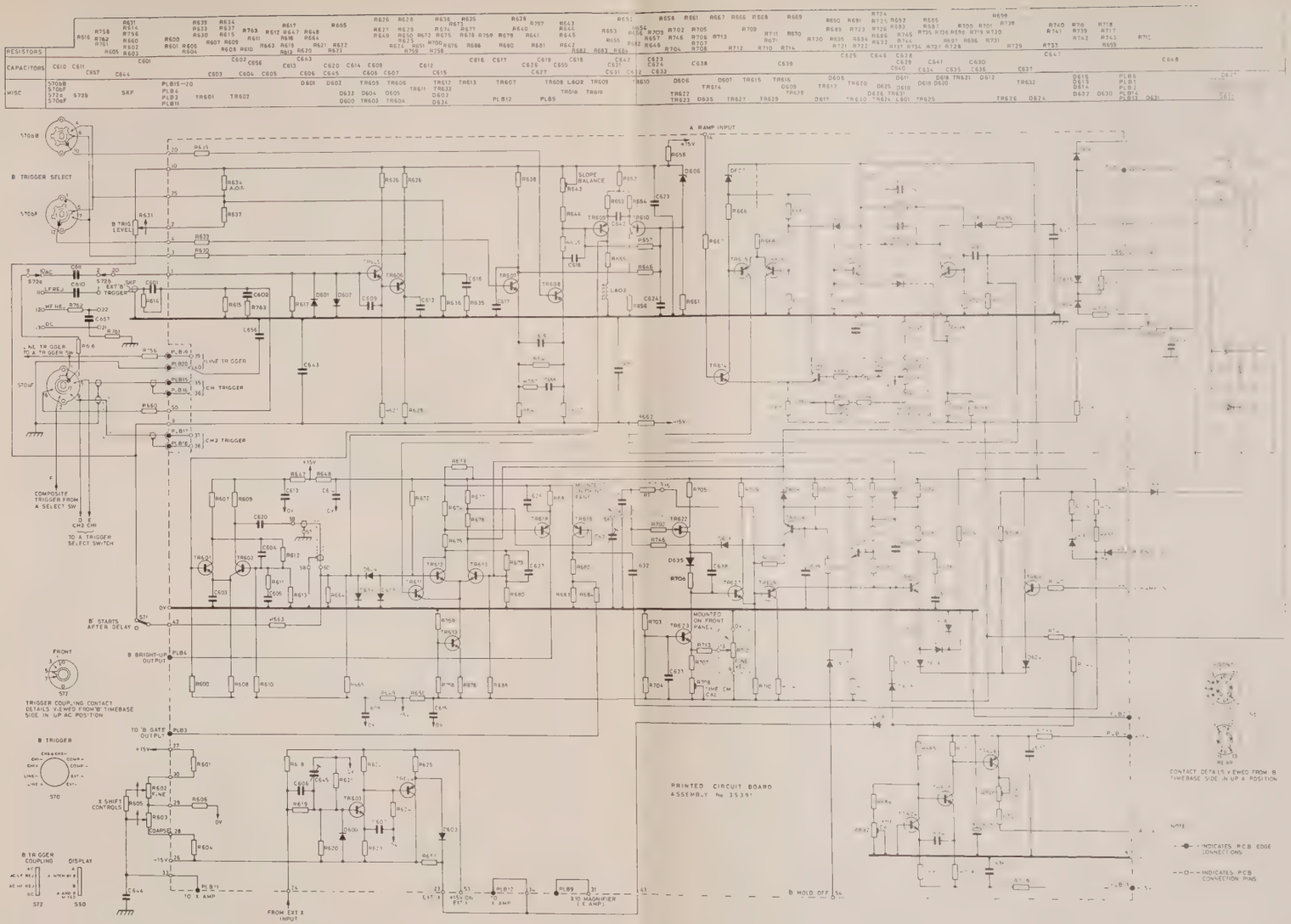


FIG.6. CIRCUIT DIAGRAM, B TIME BASE (AO/SK2405)

'X' O/P BRIGHT UP & P.C.B. INTERCONNECTION

Ref	Value	Description	Tol%±	Part No
RESISTORS				
R900	10	CF		21793
R901	33	CF		28712
R902	33	CF		28712
R903	47k	CF		21815
R904	68k	CF		21816
R905	47k	CF		21815
R906	330	CF		28721
R907	4k7	MO		26722
R908	3k9	CF		21804
R909	5k1	MO		28794
R910	680	CF		28723
R911	100	CF		21794
R912	47k	CF		21815
R913	22k	CF		18566
R914	47k	CF		21815
R915	10k	CF		21809
R916	39k	CF		28728
R917	100	CF		21794
R918	2k2	CF		18554
R919	47k	CF		21815
R920	68k	CF		21816
R921	4k7	CF		21805
R922	1k8	CF		28725
R923	27k	MO		28808
R924	47	CF		28714
R925				
R926	15k	CF		28727
R927	3k6	CF		26725
R928	1k	CF		21799
R929	5k6	CF		21806
R930	1k5	CF		21801
R931a	1k5	MO		35365
R931b	820	MO		35364
R932	1k	CF		21799
R933	2k2	CP		25362
R934	390	CF		28713
R935	100	CF		21794
R936	2k2	CF		21802
R937	110	MO		28783
R938	150	CF		28719
R939	1k	CF		21799
R940	27	CF		28711
R941a	1k5	MO		35365
R941b	820	MO		35364
R942	100	CF		21794
R943	100	CP		35361
R944	220	CF		21796
R945	47	CF		28714
R946				
R947	1k	CF		21799
R948	15k	CF		28727
R949	27k	MO		28808
R950	4k7	CF		21805
R951	10	CF		21793
R952	10	CF		21793
R953	1k8	CF		28725
R954	100	CF		21794
R955	100	CF		21794
R956	560	CF		21798
R957	10	CF		21793
R958	10	CF		21793
R959				
R970	4k7	CF		21805
R971	2k4	MO		26729
R972	47	CF		28714
R973	3k9	MO		26724
R974	5k6	CF		21806
R975	1k8	CF		18553
R976	100	CF		21794
R977	27k	MO		28808
R978	43k	MO		28813
R979	27k	CF		21813
R980	13k	MO		28803
R981	10	CF		21793
R982	47k	CF		21815
R983	10	CF		21793
R984	10	CF		21793
R985	470	CF		21797
R986	10	CF		21793
R987	13M	MO		35366
R988	1M	MO		35363
R989	1M	CF		31840
R990	10k	CF		21809
R991	100k	CF		21819
R992	10k	CF		21809
R993	43k	MO		28808
CAPACITORS				
C901	.01µF	CE(2)		22395
C902	47µF	E	25V	32182
C903	.01µF	CE(2)		22395
C904	.01µF	CE(2)		22395
C905	.1µF	PE	160V	31377
C906	.01µF	CE(2)		22395
C921	27pF	CE(2)		22369
C922	3.3pF	CE(2)		817
C923	82pF	CE(2)	A.O.T.	22374
C924		Enamelled Cu Wire Trimmer		
C925	27pF	CE(2)		22369
C926		Enamelled Cu Wire Trimmer		
C927	.01µF	CE(2)		22395
C928	.01µF	CE(2)		22395
C929	.01µF	CE(2)		22395
C930	33pF	CE(2)		22370
C970	.01µF	CE(2)		22395
C973	2.7pF	CE(2)		816
C974	820pF	CE(2)		22386
C975	.01µF	CE(2)		22395
C976	.1µF	PE	160V	31377
C977	220pF	CE(2)		22379
C978	.01µF	CE(2)	2kV	32066

'X' O/P BRIGHT UP & P.C.B. INTERCONNECTION

Ref	Value	Description	Tol%±	Part No
CAPACITORS (Contd.)				
C979	.01μF	CE(2)	2kV	32066
C980	2200pF	CE(2)		22389
C981	.01μF	CE(2)	2kV	32066
C982	.01μF	CE(2)		22395
C983	.01μF	CE(2)		22395
C984	.01μF	CE(2)		22395
TRANSISTORS				
TR901		BC107		26790
TR902		2N3906		21533
TR903		BC108		26110
TR921		2N2369		23307
TR922		2N2369		23307
TR923		2N2369		23307
TR924		2N2369		23307
TR925		2N2369		23307
TR926		BF457		35360
TR927		BF457		35360
TR928		2N2369		23307
TR929		2N2369		23307
TR970		2N2369		23307
TR971		BSV46		50585
TR972		BC190A		35359

Ref	Value	Description	Tol%±	Part No
DIODES				
D901		IN4148		23802
D902		IN4148		23802
D903		IN4148		23802
D921		IN4148		23802
D922		IN4148		23802
D923		IN4148		23802
D924	4V7	Zener		33927
D925		IN4148		23802
D970		IN4148		23802
D971		IN4148		23802
D972		IN4148		23802
D973		IN4148		23802
D974		IN916		1949
D975		IN916		1949
D976		IN4148		23802
MISCELLANEOUS				
RL921				35357
L921				26986
L970				26986
N971				26845
N972				26845
SKA				31240
SKB				31241
SKC				31241

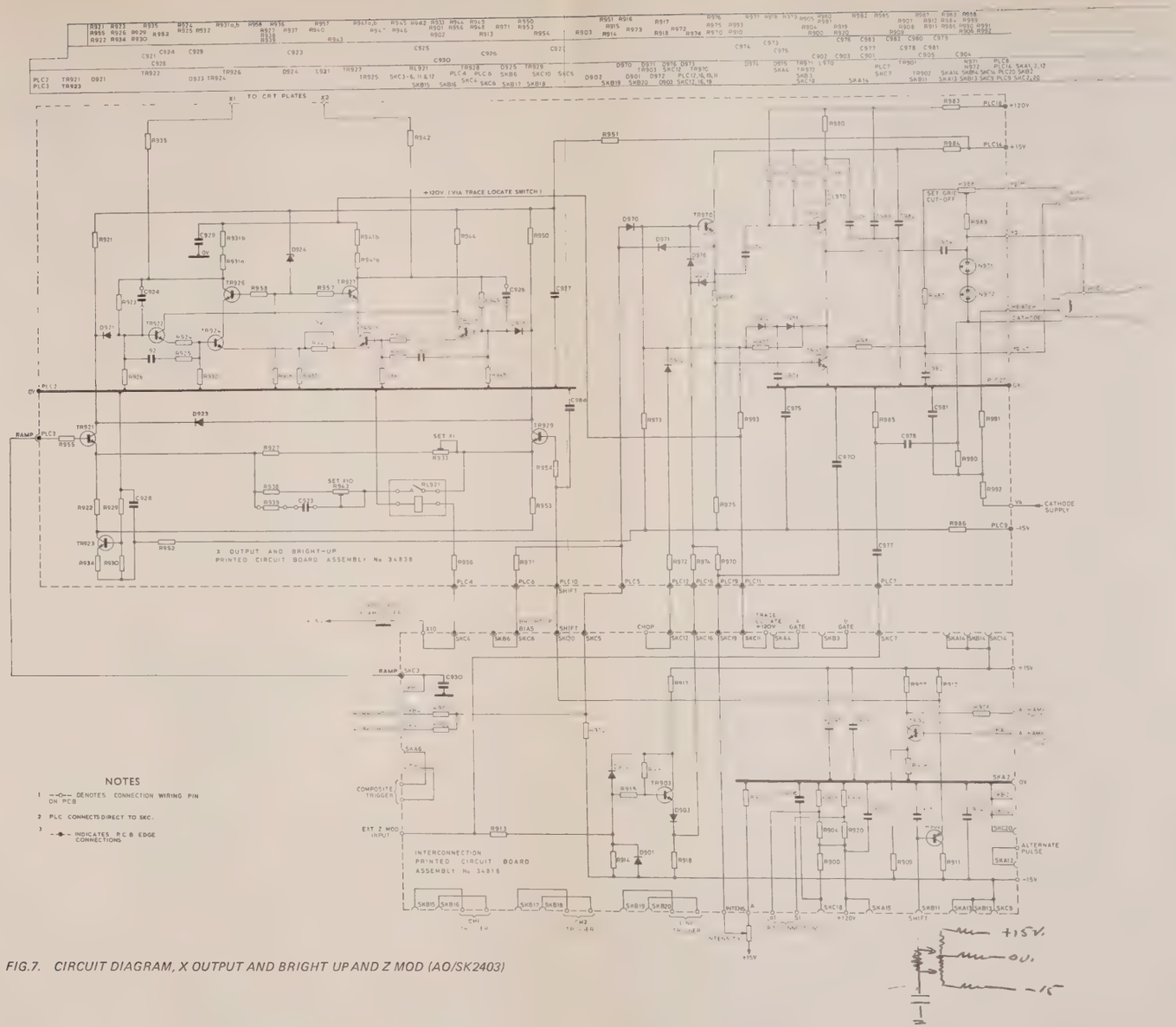

TO CRT PLATES
+120V (VIA TRACE LOCATE SWITCH)
X OUTPUT AND BRIGHT-UP PRINTED CIRCUIT BOARD ASSEMBLY No. 34838
INTERCONNECTION PRINTED CIRCUIT BOARD ASSEMBLY No. 34816
CATHODE SUPPLY
ALTERNATE PULSE
NOTES
1 DENOTES CONNECTION WIRING PIN ON PCB
2 PLC CONNECTS DIRECT TO SKC.
3 INDICATES P.C.B EDGE CONNECTIONS

FIG.7. CIRCUIT DIAGRAM, X OUTPUT AND BRIGHT UP AND Z MOD (AO/SK2403)

Component List and Illustrations

Section 6

POWER SUPPLY & EHT OSCILLATOR

Ref	Value	Description	Tol%±		Part No
RESISTORS					
R83	68k	CF			21816
R84	47	WW	±5	6W	18737
R86	4k7	CF		1/8 W	21805
R801	390	WW		3W	26766
R802	470	CF			21797
R803	470	CF			21797
R804	680k	CF			31839
R805	680k	CF			31839
R806	680k	CF			31839
R807	680k	CF			31839
R808	680k	CF			31839
R809	680k	CF			31839
R810	2R2	WW	±5	2½W	31894
R811	1k	CF			21799
R831	22	CF		1W	19028
R832	470	CF	±5	1/8 W	21797
R833	180	CF	±5	1/8 W	21795
R834	3k3	CF	±5	1/8 W	21803
R835	1	WW		3W	31890
R836	OR82	WW		2½W	31899
R837	7k5	MO	±2		28797
R838	1k	PCP			26870
R839	6k8	MO			28796
R840	820	CF			28724
R841	2k7	CF		1W	19043
R842	33k	MO			28810
R843	3k6	MO			26725
R844	4k7	CF			21805
R845	1k	CF			21799
R846	4k7	CF			21805
R847	7k5	MO			28797
R848	7k5	MO			28797
R849	100	CF			21794
R850	1k	PCP			27156
R851	270	CF			28720
R852	120	CF	±5		28718
R853					
R854	10k	PCP			28525
R855	3k3	CF			21803
R856	100	CF			21794
R857	100	CF			21794
R858	470k	CF			32330
R859	120	CF			28718
R860	2k2	CF			21802
R861	4k7	CF			21805
R862	1	WW		3W	31890
R863	47k	CF			21815
R864	10k	CF			21809
R866	1k	CF			21799
R867	2k7	CF			28726
R868	39k	CF			28728
R869	100k	CF			21819
R870	270	CF			28720

Ref	Value	Description	Tol%±	Part No
CAPACITORS				
C83	100μF	E	275V	24740
	200μF			
C84	4700μF	E	40V	31919
C85	4700μF	E	40V	31919
C86	100μF	E	275V	24740
	200μF			
C87	.22μF	PE	400V	31396
C88	4.7μF	PE	160V	32195
C801	.01μF	CE(2)		22395
C802	.01μF	CE(2)		22395
C803	22μF	E	25V	32181
C804	.01μF	PE	160V	31377
C805	.02μF	CE(2)	1.5kv	25223
C806	.02μF	CE(2)	1.5kv	25223
C807	82pF	CE(2)		22375
C808	82pF	CE(2)		22375
C831	10μF	E	25V	32180
C832	100pF	CE(2)		22376
C833	.01μF	CE(2)		22395
C834	3300pF	CE(2)		22391
C835	10μF	E	25V	32180
C836	.01μF	CE(2)		22395
C837	.01μF	CE(2)		22395
C838	.01μF	CE(2)		22395
C839	22μF	E	25V	32181
C840	1500pF	CE(2)		22395
C841	10μF	E		32180
TRANSISTORS				
TR801		BFY50		26112
TR802		BFY50		26112
TR831		BC212k		29327
TR832		2N2369		23307
TR833		BC108		26110
TR834		BC108		26110
TR835		MM1614		19320
TR836		MM1613		19323
TR837		MJE 520		24739
TR838		MJE520		24739
TR839		2N5296		28630
TR840		BC108		26110
TR841		BC108		26110
TR842		BCY70		23354
TR843		MJE520		24739
DIODES				
D83		IN4003		23462
D84		IN4003		23462
D85		IN4007		52337
D86		IN4007		52337
D87	56V	Zener		35760
D801		IN4148		23802
D802		IN4148		23802
D831		IN4148		23802
D832		IN4148		23802

Ref	Value	Description	Tol%±	Part No
D833		IN4148		23802
D834		IN4148		23802
D835		IN4003		23462
D836		IN4003		23462
D837		IN4148		23802
D838		IN4148		23802
MISCELLANEOUS				
MR81		WO4		29367
MR82		IN4003	4 off per	23462
MR83		WO2		19725
S80		With R60		A4/31224
S81				35242
IC801		μA723C		31228
L801				A3/35328
L802				26986
T83				A1/34918
T801				A3/35295
N80				26586
FS83		SLO-BLO	1A	34790
FS831			250mA	32338
FS832			500mA	32339
FS833			1A	52162
FS834			1A	52162

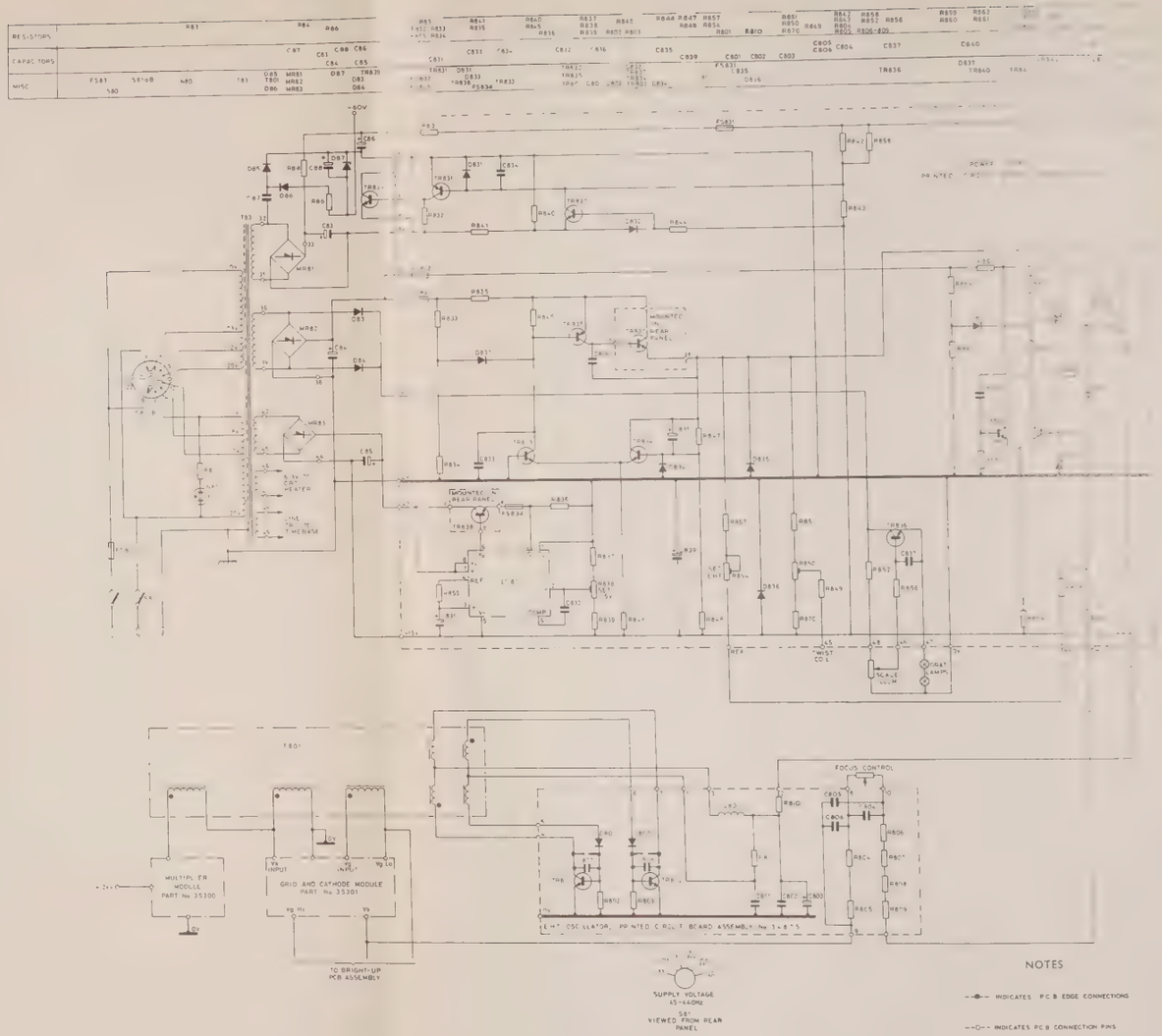


FIG.8. CIRCUIT DIAGRAM, POWER SUPPLY AND EHT SUPPLY (AO/SK2399)

INTERCONNECTION

Ref	Value	Description		Tol%±	Part No
RESISTORS					
R28	39	CF			28713
R29	39	CF			28713
R30	68	CF			28716
R31	68	CF			28716
R32	180	CF			21795
R33	180	CF			21795
R60	4K7	CP	With S80		A1/31224
R80	470K1	CP			A4/31222
R81	100K	CP			A4/35941
R82	4K7	CP			A4/31223
R85	1K	WW			2676
R507	10K	CP			A4/34780
R561	4M99	MF		±0.5	35818
R562	3M	MF		±0.5	35817
R563	1M	MF		±0.5	35816
R564	499K	MF		±0.5	35815
R565	300K	MF		±0.5	35814
R566	100K	MF		±0.5	35813
R567	49K9	MF		±0.5	35812
R568	30K	MF		±0.5	35811
R569	10K	MF		±0.5	35810
R570	10K	MF		±0.5	35810
R712	10K	CP			A4/34780
R732	100	MF		±0.5	35581
R747	3M	MF		±0.5	35817
R748	1M	MF		±0.5	35816
R749	499K	MF		±0.5	35815
R750	300K	MF		±0.5	35814
R751	100K	MF		±0.5	35813
R752	4K9	MF		±0.5	35812
R753	30K	MF		±0.5	35811
R754	10K	MF		±0.5	35810
R755	10K	MF		±0.5	35810
R760	900	MF		±0.5	35582
CAPACITORS					
C21	2.7pF	CE(2)			816
C22	.01μF	CE(2)			22395
C23	1.5pF	CE(2)			813
C456	68pF	CE(2)			4513
C457	1μF	CE(2)		±1 160V	24888
C458	.1μF	CE(2)		±1 160V	24887
C459	.01μF	CE(2)		±1 160V	24886
C460	900pF	CE(2)		±1 125V	24885
C461	100pF	CE(2)			22376
C649	1μF	CE(2)		±1 160V	24888
C650	.1μF	CE(2)		±1 160V	24887
C651	.01μF	CE(2)		±1 160V	24886
C652	900pF	CE(2)		±1 125V	24885
C653	56pF	CE(2)			30544
C654	10pF	CE(2)			22364
MISCELLANEOUS					
L83					24914
LP1					35471
LP2					35471
V83		Thorn D14-210GH Standard			35450
		Thorn D14-210GM Long Persistence			35451
PLD		Connector Type CEE 22			33787
TP601					24159
TP602					24159
S12		With R26			A4/31257
S22		With R27			A4/31257
S31					31226
S43					31280
S51					35502
S73					31278
S74		Part of R507			
S75		Part of R712			
S201					
SKD					1222

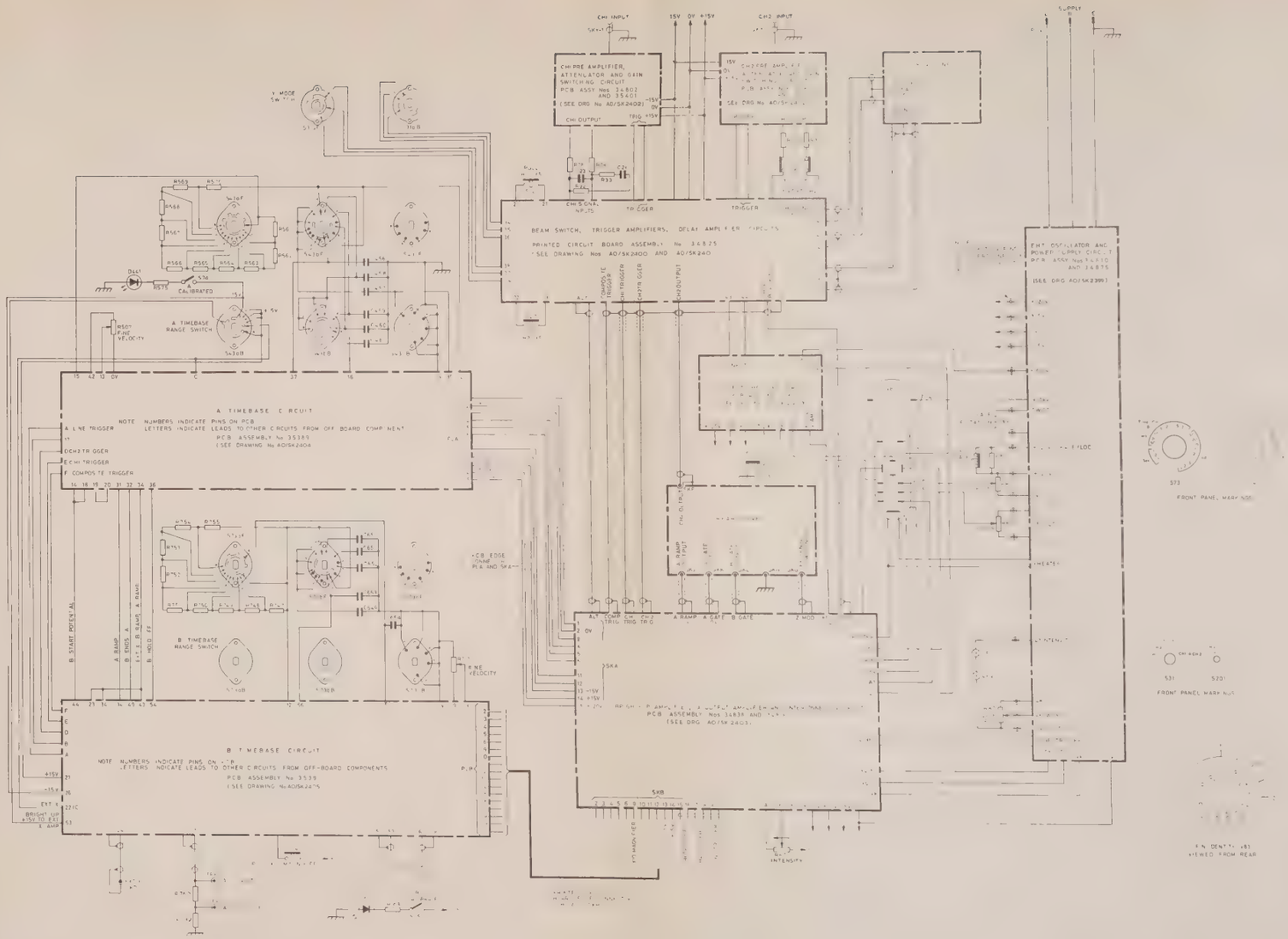

CH1 INPUT
CH2 INPUT
CH1 PRE AMPLIFIER, ATTENUATOR AND GAIN SWITCHING CIRCUIT
PCB ASSY Nos 34802 AND 35401
(SEE DRG No AO/SK2402)
CH1 OUTPUT
CH2 PRE AMP. P.C.B.
BEAM SWITCH, TRIGGER AMPLIFIERS, DELAY AMPLIFIER CIRCUITS
PRINTED CIRCUIT BOARD ASSEMBLY No 34825
(SEE DRAWING Nos AO/SK2400 AND AO/SK2401)
A TIMEBASE RANGE SWITCH
A TIMEBASE CIRCUIT
NOTE NUMBERS INDICATE PINS ON PCB
LETTERS INDICATE LEADS TO OTHER CIRCUITS FROM OFF BOARD COMPONENT
PCB ASSEMBLY No 35389
(SEE DRAWING No AO/SK2404)
B TIMEBASE RANGE SWITCH
B TIMEBASE CIRCUIT
NOTE NUMBERS INDICATE PINS ON PCB
LETTERS INDICATE LEADS TO OTHER CIRCUITS FROM OFF-BOARD COMPONENTS
PCB ASSEMBLY No 35539
(SEE DRAWING No AO/SK2405)
CALIBRATED
FINE VELOCITY
PCB EDGE CONNECTOR PIN AND SKT
INTENSITY
573
FRONT PANEL MARKING
531
570
FRONT PANEL MARKING
VIEWED FROM REAR

FIG.9. CIRCUIT DIAGRAM, INTERCONNECTION (AO/SK2398)

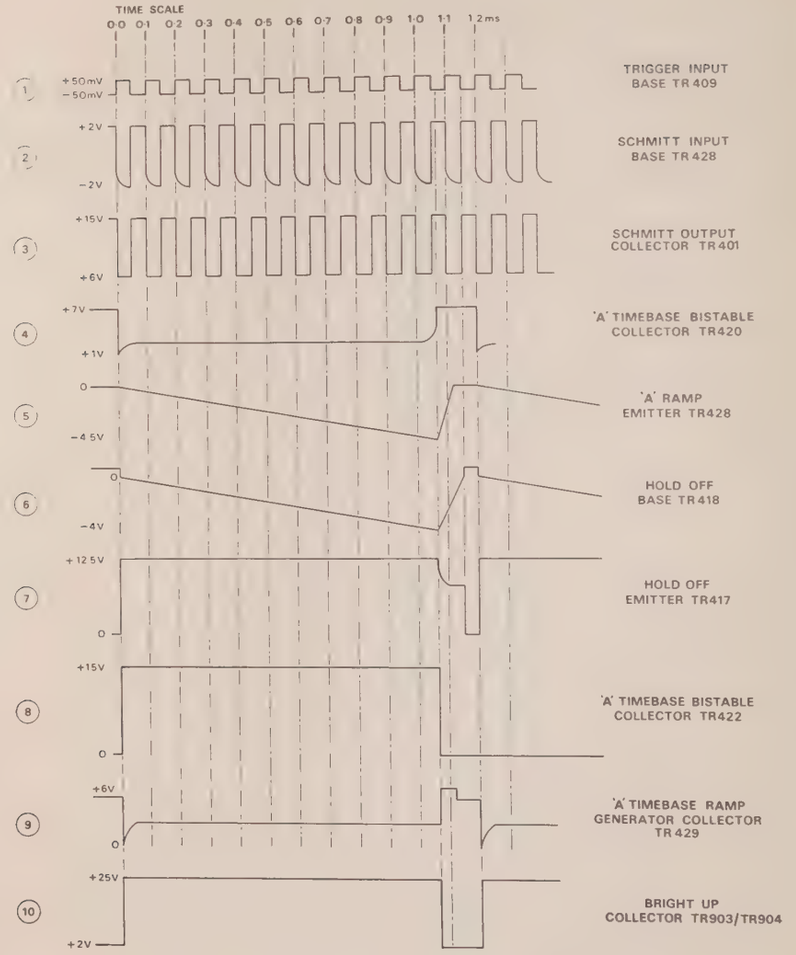


Fig. 10 Waveform Diagram Normal A Sweep

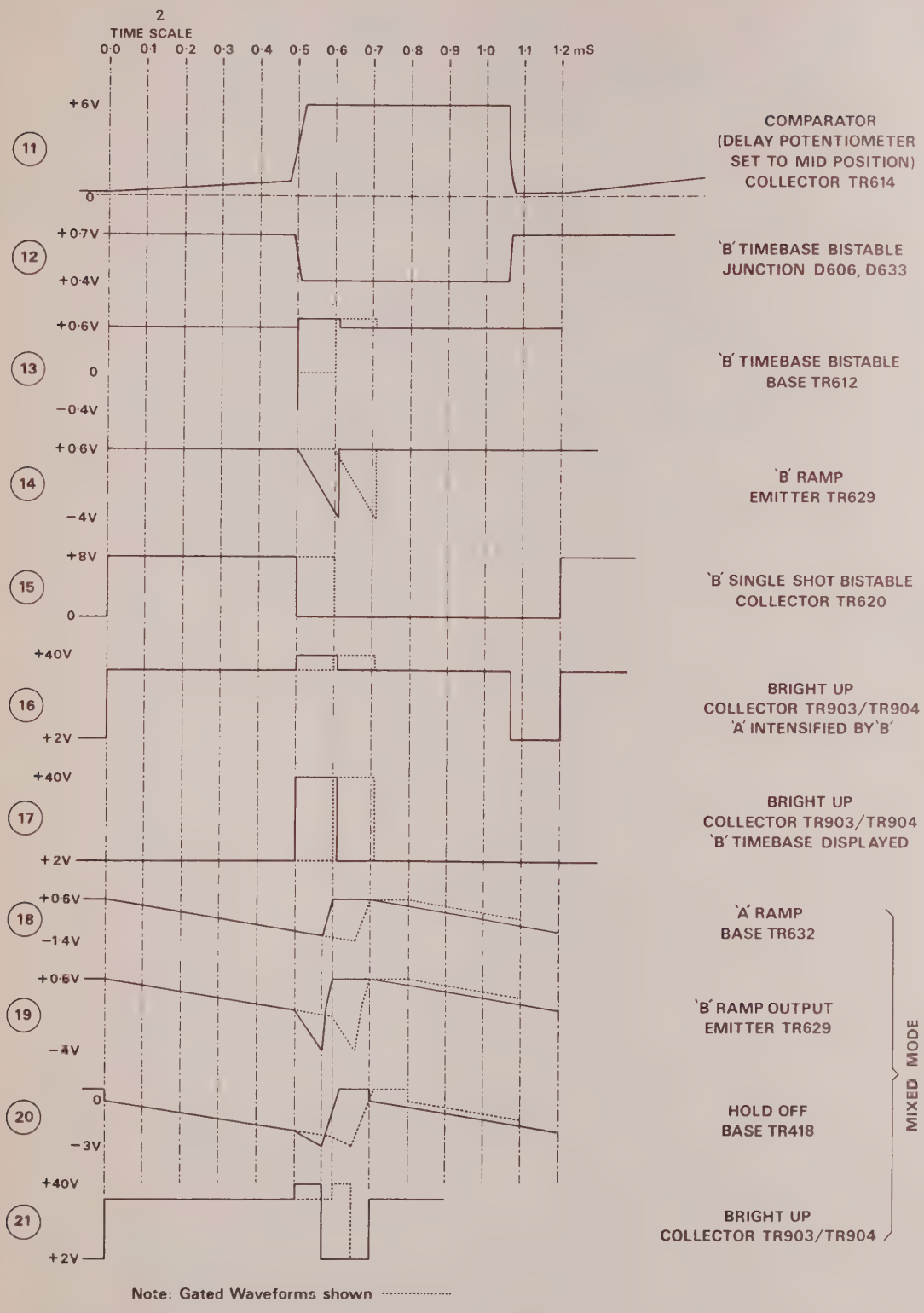


Fig. 11 Waveform Diagram Dual Timebase Operation

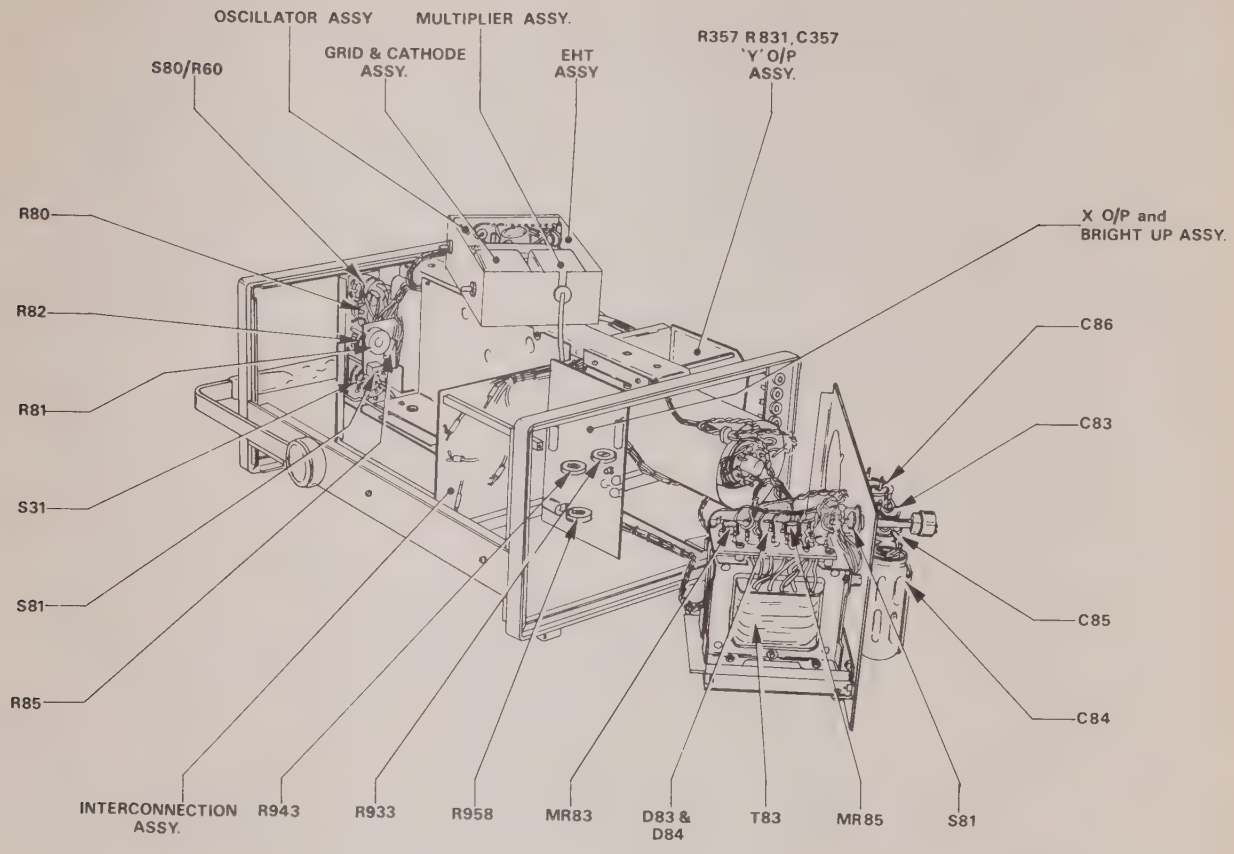


Fig. 12 Main Frame showing access to Power supply and EHT unit

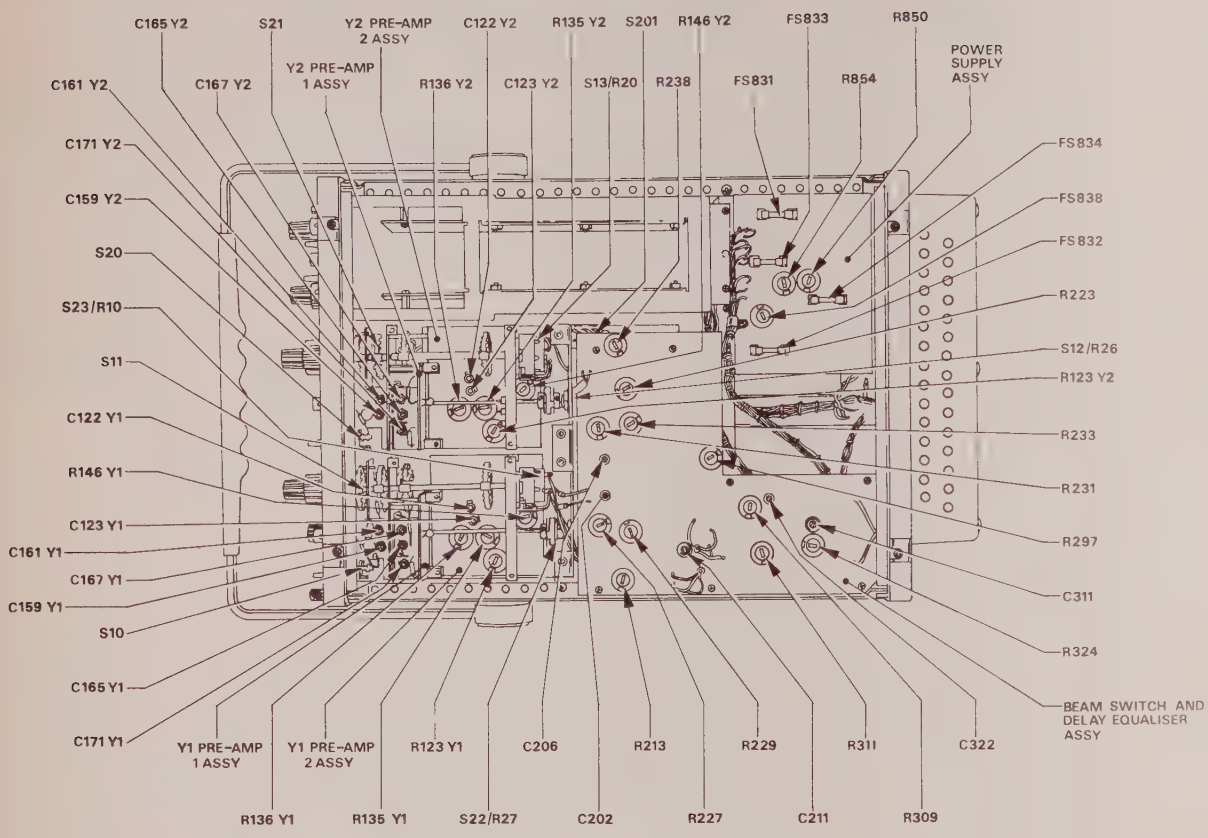


Fig. 13 Underside View

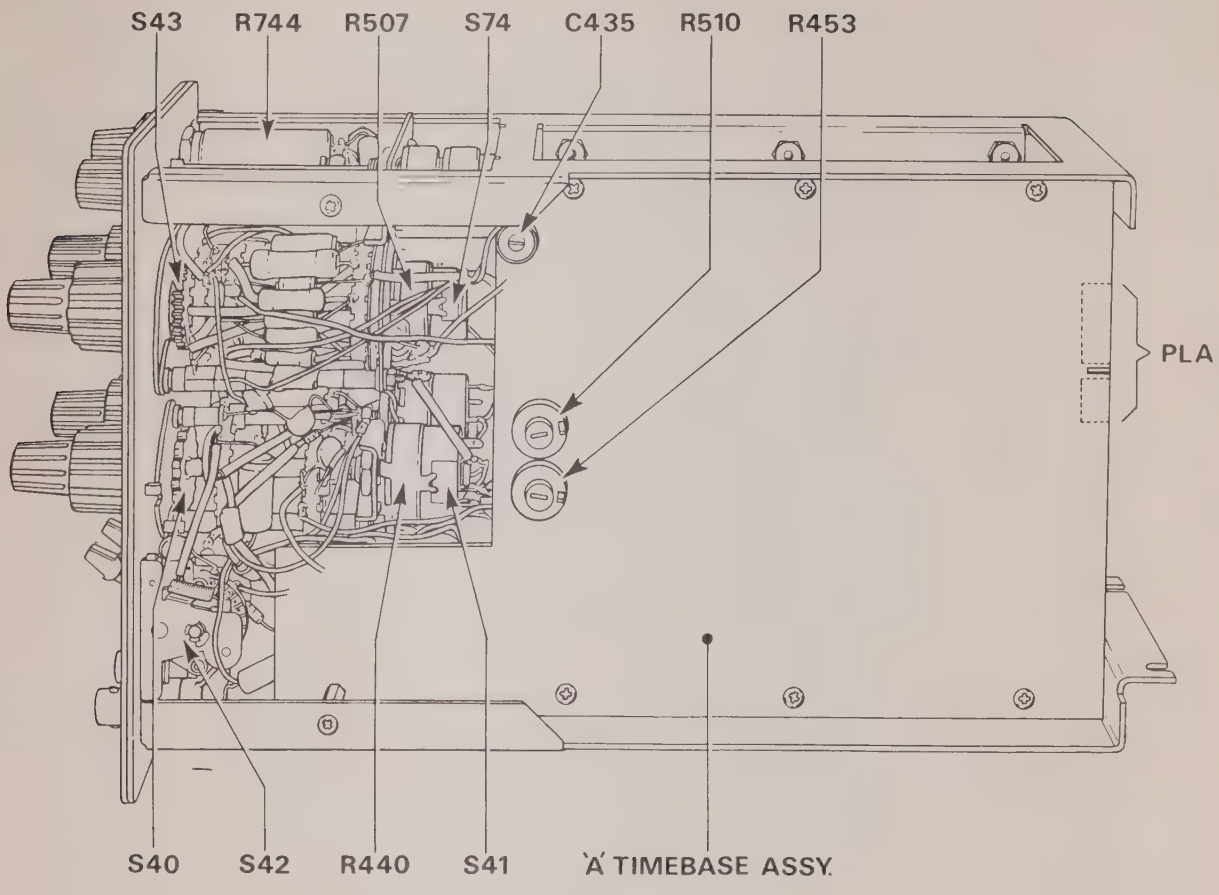


Fig. 14 Timebase Unit A side

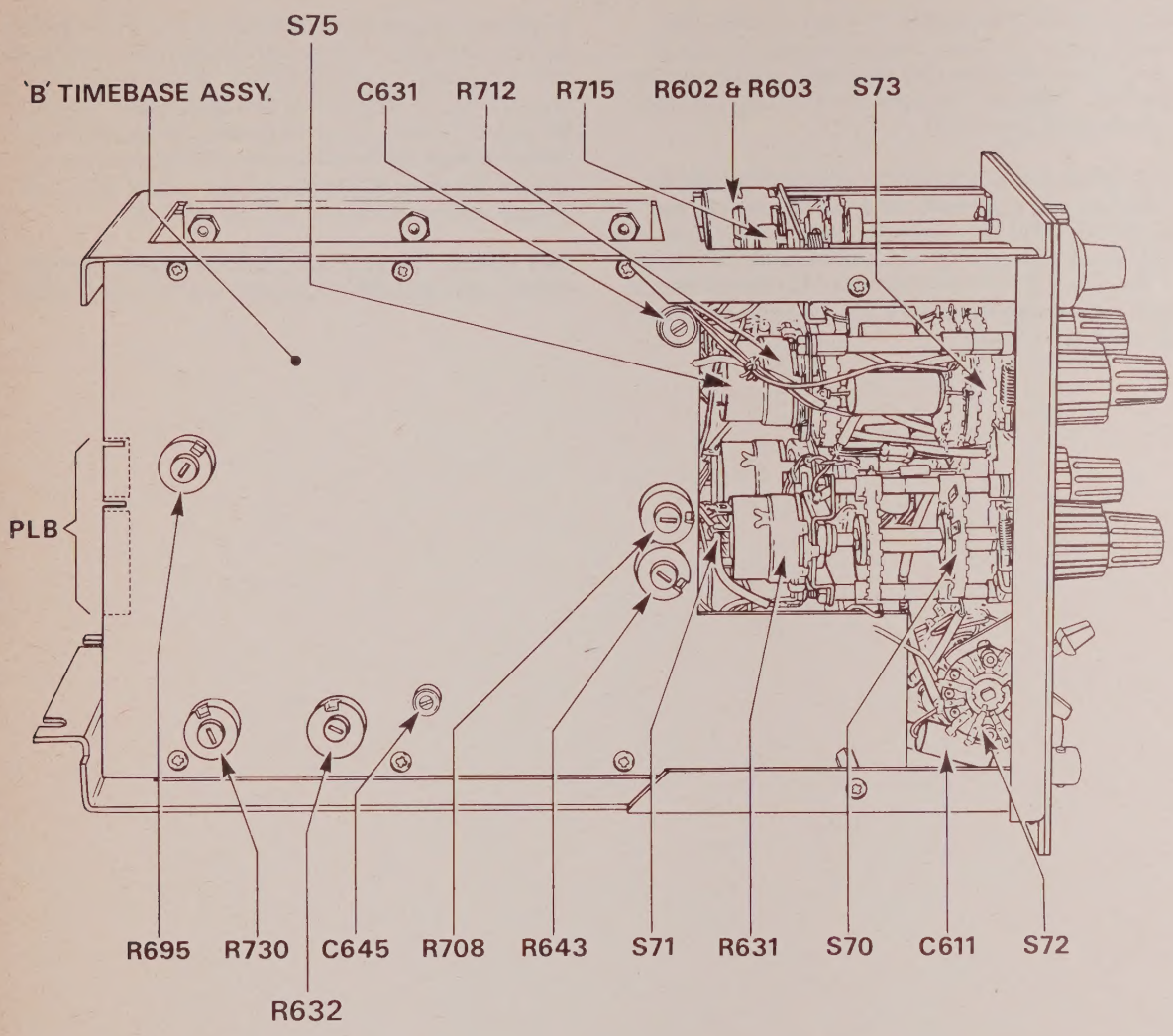


Fig. 15 Timebase Unit B side

Guarantee and Service Facilities

Section 7

This instrument is guaranteed for a period of one year from its delivery to the purchaser, covering the replacement of defective parts other than tubes, semiconductors and fuses. Tubes and semiconductors are subject to the manufacturers' guarantee.

We maintain comprehensive after sales facilities and the instrument can, if necessary, be returned to our factory for servicing. The type and serial number of the instrument should always be quoted, together with full details of any fault and the service required. The Service Department can also provide maintenance and repair information by telephone or letter.

Equipment returned to us for servicing must be adequately packed, preferably in the special box supplied, and shipped with transportation charges prepaid. We can accept no responsibility for instruments arriving damaged. Should the cause of failure during the guarantee period be due to misuse or abuse of the instrument, or if the guarantee has expired, the repair will be put in hand without delay and charged unless other instructions are received.

OUR SALES, SERVICE AND ENGINEERING DEPARTMENTS ARE READY TO ASSIST YOU AT ALL TIMES.

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